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UTILIZATION OF SCIENCE BY INDUSTRY

THE view that new scientific and technical knowledge is absorbed into certain sections of British industry too slowly, and that a scientific approach to the day-to-day problems of production and organization is less common than it should be, is widely held. It was emphasized by Sir Henry Tizard in his presidential address to the British Association more than five years ago, and it has since been accepted by the Advisory Council on Scientific Policy and found some support in the reports coming from the productivity teams of the Anglo-American Productivity Council. It was subjected to detailed analysis by Dr. R. L. Meier in his paper "The Role of Science in the British Economy" and, although in some quarters this view is regarded as mistaken, the Manchester Joint Research Council was fully justified in accepting it for the purpose of its inquiry into the relations between science and industry in the Greater Manchester area*.

This inquiry, carried out in the main by a team of three investigators, guided by a Steering Committee, during 1950–53, was not primarily concerned to discover whether this opinion is right or wrong. The investigators were interested rather in examining the reasons usually given for the alleged backwardness of British industry in this respect. The inquiry was limited to some 225 firms each employing more than fifty persons in an area of south-east Lancashire from Blackburn and Burnley to Stalybridge, Stockport and Altrincham. Some 76 per cent of the firms approached responded, and in the textile industries 20 per cent of the establishments in the area were eventually visited; in the engineering industries 17 per cent of the firms were visited; in the modern industries group, concerned with the manufacture of materials or articles unknown to society or industry a century or even fifty years ago, 22 per cent were visited; and of those in miscellaneous industries, 23 per cent.

In presenting this report, therefore, the Manchester Joint Research Council believes that the facts recorded are sufficiently representative to give a reliable basis for tentative conclusions as to the answers to some of the leading questions which at once arise out of any assumption as to the backwardness of British industry. Sometimes, for example, this is attributed to the relatively small number of scientists employed in industry, or to the absence of men of the right type or appropriate training. Alternatively, it is argued that industry does not make the best use of the scientists it does employ, or that the alleged backwardness is due to weaknesses in the organization of research and development and in their relation to production; or again, that the lack of scientific enterprise in industry is due to government control, to restrictive practices by management or labour, or to the general level of taxation.

* Industry and Science: a Study of their relationship based on a survey of firms in the Greater Manchester Area carried out by the Manchester Joint Research Council, 1950–1953. Pp. viii+188. (Manchester: At the University Press, 1954.) 12*s.* 6*d.* net.

On the validity of these last arguments, the report expresses no opinion; but, with this exception, the Steering Committee organized its inquiry so as to throw as much light on the questions that immediately arise out of the foregoing criticisms. Without expecting that the inquiry could by itself provide a conclusive answer to the arguments, it sought, for example, to accumulate facts which would, at any rate indirectly, indicate whether employment of scientists led to a progressive atmosphere and whether the presence of scientists at the higher levels of management or on the directorate made any crucial difference in the attitude or practice of the firm. In the same way, the relations between the universities and the research associations were examined so as to throw light on the question whether directly or indirectly they provided sufficient basis for all requirements, or whether there was a need and demand for new institutions. Next, light was sought on the respective roles in industry of the universities, the research associations and the research departments, their interrelationships, and the role of research and development departments in the firms themselves and the relation of these departments to other branches of the firm. These questions, moreover, are related to the earlier questions about the employment of scientists in industry, and the investigators sought specifically to throw some light on these relations between the use of scientists in industry and problems of organization and institutions.

Although the inquiry covers but a small sample of industry in Britain, it touches a wide range of problems, and the facts recorded are a useful contribution to the current discussion of such varied topics as scientific man-power and higher technological education, education for management, the functions of the research associations, the relations between universities and industry, the work of the National Research Development Corporation, information services and the like. It is less searching and exhaustive in its treatment of the research associations than either Prof. R. S. Edwards's study, or the particular analysis of the work of the British Leather Manufacturers' Research Association which the Department of Scientific and Industrial Research made three years ago; but the important questions are nevertheless asked, and at least some indication given as to where the answers lie. Moreover, the ultimate value of the survey may well lie in its firm warning against facile generalizations. Generalizations covering the whole field of British industry regarding the use which is, or should be, made of scientists and technologists may be wholly unjustified.

Although there is no uniform pattern, however, the information collected affords fairly solid grounds for the belief that the extent to which industry in Britain makes the maximum use of the possibilities for scientific assistance depends directly on the outlook of the management at the head of each particular firm. The investigation revealed no evidence that scientists are, to any material extent, wastefully employed: there is no reference to wasteful employment practices, particularly in the engineering field, that result in inefficient utilization of professional manpower, such as are deplored by the National Manpower Council in the United States in its report, "A Policy for Scientific and Professional Manpower", and have also been noted there by the American Society for Engineering Education and the National Society for Professional Engineers. Even if, on the contrary, there is no real justification for the belief that in Britain a shortage of scientists is the basic cause of any existing backwardness, difficulties in recruiting a really adequate supply of scientists for industry—of which the investigators noted some signs—are likely to discourage any failure to make the best possible use of those actually employed.

The dominant impression left by this study is that the attitudes of those directing the firms consulted is the decisive factor. Such changes as have come about in the past decade or two are the result of a changed 'climate' of thinking in the highest management circles. To that extent the inquiry confirms all that Dr. K. T. Compton said as to the importance of this climate of opinion in his address to the Parliamentary and Scientific Committee at its annual luncheon on February 16. The importance of higher technological education is very far from being limited to its direct effect on the supply of scientists or technologists: its influence permeates widely into society, and helps to develop the industrial and social climate in which technological progress and productivity can thrive.

It is worth noting in this connexion that the investigators found a surprisingly high proportion of science graduates occupying seats on boards of directors. Out of a total of 684 graduates employed in the firms visited, 93 were directors; and these were distributed over 70 of the 99 firms which were found to be employing graduates. Moreover, 74 of these graduates had reached this level by their own efforts, unassisted by family associations, but by way of positions involving day-to-day contacts with the firm's industrial, as distinct from purely research, activities. That position is perhaps more encouraging than might have been expected; but if in a high proportion of these firms direction of policy lies to some extent in the hands of scientifically trained men, the inquiry left the definite impression on the investigators that for those firms without qualified staff, as a whole, the services of a trained scientist or technologist capable of undertaking skilled supervision of processing efficiency would usually have been of real value.

The investigators recognized very clearly that no general criterion of satisfactory use of science in industry is available. Conditions vary too widely for any common standard to be applicable, and this to some extent must apply also to the nature and extent of the research conducted by a particular industry. That has its bearing on the work and functions of the research associations; and while the survey emphasizes the importance of the contribution of the research associations, it directs attention at the same time to the limitations of the research association movement and of the part the research associations can be expected to play in furthering

the use of science in industry. It is generally believed that, within their limitations, the work of the research associations is well done and is appropriate to the industry concerned. Such associations even now, however, do not cover the whole of industry, and the report suggests that they might with advantage increase their technical contacts with their member firms.

Too much must not be made of an investigation which at best is only a sample, and in which no scale of comparison elsewhere is possible. Nevertheless, the findings of the Manchester Joint Research Council, even though they rest on the personal judgment and experience of the investigators, suggest that any considerable expansion of the research association movement in Britain is a matter for careful forethought. No such expansion on the scientific research side is suggested in this report; but rather, increased effort in the technological and liaison work. The hope seems to be that by fostering a scientific outlook within the member firms, there may be a more effective application of existing knowledge and, apart from a better use of the facilities which research associations already provide, even a wider prosecution of research within the firm itself. The investigators seem to have no doubt in their own minds that such research is by far the most effective, however much it may draw on existing fundamental knowledge accumulated co-operatively in the research associations or at the universities.

A further encouraging feature of British industry revealed by this report is a much wider and closer contact with the universities than had been expected. This contact occurs in dealing with scientific or technical problems arising in actual production, where some new technique or particular experience available at the university may help to resolve a difficulty, rather than from consideration of the broader problems of training, recruitment or management research such as have formed the subject of conferences arranged between the Federation of British Industries and the universities. Nevertheless, it is true that more and better liaison is still required, and that there are ways in which the universities can assist in the further training of those who have already entered industry. However, the inquiry has revealed that immense resources of science are still untapped by industry and that more bridges between industry and science and greater mutual respect between the two are still prime needs in Britain; it has equally demonstrated that in certain fields British industry has most effectively enlisted already the resources of science. The investigators are right to condemn the unwarrantable depreciation of our achievements in discussing the use which British industry makes of science, with the attendant lowering of national prestige and discouragement of the coming generation of scientists and industrialists.

On the whole, the survey affords little support for the view, pressed rather strongly by Mr. John Edwards in the House of Commons at the second reading of the Development of Inventions Bill, that the resources of Great Britain are so distributed as to cause a lack of balance between those devoted to fundamental research and those devoted to development. Mr. Edwards did not advocate any reduction in fundamental research, and neither does the present report; but the latter suggests that more effective channels of information rather than any considerable increase of development is the primary need. The functions of the National Research Development Corporation as a provider of risk capital, in any event, lie outside the limits which the Manchester investigators deliberately set themselves, and their comments on the activities of the Corporation are limited to the strong suggestion that the Corporation is not yet sufficiently widely known to play effectively the part it was created to fulfil.

How important or permanent that part may be is unlikely to be indicated by studies such as that which has just been carried out by the Manchester Joint Research Council. We need to know more as to the causes of relatively slow development in some sectors of British industry before a sound judgment is possible here. Light is likely to come from the detailed study of a few selected major research and development projects in which Britain is regarded as having lagged behind. Such an analysis, moreover, must take full account of those fiscal factors and restrictive practices which were excluded from this survey, and on which Sir Henry Tizard commented forcefully in his Messel Memorial Lecture a year or two ago. Financial and fiscal policies in themselves can easily form a climate of opinion, and encourage or discourage practices both on the part of employers and employed which are inimical to enterprise and the vigorous and uninhibited development of new ideas.

Few, if any, new ideas emerge from this report. It affords, so far as it goes, a notable amount of support for the existing structure for the organization of research in Britain, and shows very clearly that decisions to expand any particular sector should be taken not in isolation but in the light of full consideration of other claims on the country's resources, and in the light of the effect upon other sectors. For example, little interest was evinced in sponsored research; but the investigators suggest that there might be room for an institution of this character to work in the limited fields of chemical and electrical engineering. The major task, especially where industry is not yet making full use of science, is one of education. What aid science can bring to many branches of industry has not yet been expounded adequately from a point of view calculated to convince the ordinary business man. Liaison and education are needed to a far greater degree than more and better science.

The implications of this situation are not fully explored in this survey, nor indeed could they have been. There is evidence enough, to which reference has already been made, to suggest that we can await with some confidence the outcome of the slow process of persistent liaison and education from both sides, which the investigators themselves recognize as the policy likely to secure the best results, rather than a single act of policy either in the field of education or in industry. That, however, is an additional reason for

pressing forward, with more urgency than the Government has yet displayed, with the expansion of higher technological—as well as of technical—education, and with the formulation of a policy which gives full expression to the respective contributions of the universities, the colleges of technology, the technical colleges and the research associations themselves.

In that context the expansion of the research associations is likely to proceed in step with their appropriate place in the educational structure as well as the research organization of industry, and in providing that greater flow of information to industry not only from such bodies but also from the Department of Scientific and Industrial Research, the National Research Development Corporation and all those other varied sources of new knowledge such as the universities, the learned societies and the independent research institutions. The freer and fuller flow of information can contribute to the formation of a climate of opinion which both favours the acceptance of new ideas and the recruitment into industry of those competent to appreciate the significance of new knowledge and to apply it. "The ultimate responsibility for the use of scientific knowledge, as for the introduction of any sort of new idea, lies with the board of directors and the top level of management of each firm. The personalities of such men, and their attitudes to the scientific approach to their production, is therefore a matter of predominating importance." Any shortcomings of British industry in this respect are unlikely to be removed swiftly; but on the evidence of this report the whole trend is towards a position in which—except in firms whose routine activities involve little need of scientific knowledge—it will become increasingly rare to find in industry boards of managers on which no scientist finds a place.

THE BRITISH CONTRIBUTION TO MEDICINE

The British Contribution to Medicine

By Dr. Jaime Jaramillo-Arango. Pp. xii+220+45 plates. (Edinburgh and London: E. and S. Livingstone, Ltd., 1953.) 25*s*. net.

BEFORE entering the diplomatic service, Dr. Jaime Jaramillo-Arango was an eminent surgeon in the Republic of Colombia. He spent the period of the Second World War first as minister and then as ambassador of his country in Great Britain, and as a lasting souvenir of his mission and a tribute of admiration to the war effort of "this great nation", he decided to write an account of the "British Contribution to Medicine". The book was written in Spanish primarily for the benefit of medical men in the Latin-American countries. It must be a matter of surprise to the British reader how Dr. Jaramillo-Arango as an ambassador could have made himself so familiar with the details of much modern British medical research, as is apparently the case. This is where the attractive introduction written by Sir Arthur MacNalty is so useful, for it explains how closely the author entered into the life of medicine in Britain, and not only visited universities, hospitals and laboratories but also attended medical and scientific societies and became friendly with many leaders of British medicine. There is good evidence in the book of these friendships in the descriptions of the life-history of some of the discoverers, which could only have been obtained from the individuals themselves. Personal knowledge of the research workers has also added greatly both to the factual account of the work described and to its interest, and has generally led to a better-balanced history of the work. Where the author seems to have had little or no contact with the active research workers in a particular field, as in the case of nutritional diseases, the account given is not quite so interesting and does not have the stamp of one so familiar with the subject.

Dr. Jaramillo-Arango picks out six medical discoveries of the past fifty years which he regards as almost exclusively the achievement of British medicine. These are anti-typhoid-paratyphoid inoculation, the discovery of penicillin, the role of the mosquito in the transmission of malaria, the discovery of paludrine, the discovery of vitamins, and the synthesis of stilbœstrol.

The various chapters are written around these discoveries. Sometimes, as in the case of typhoid inoculation, penicillin, and the part played by the mosquito in the transmission of malaria, each British discovery forms a major part of a chapter. In others, the British work is rightly treated as an incident in the discussion of much wider problems; thus, the discovery of stilbœstrol and, later in the United States, of its alleviating effect in cancer of the prostate, is placed in a comprehensive account of carcinogenesis and of the attempts to find curative agents of cancer. In this chapter, as might be expected, attention is given to the well-known work of Kennaway and Hieger and their colleagues at the Royal Cancer Hospital on the isolation of highly carcinogenic substances from tar.

It would be wrong to assume that British contributions even where, as in the case of penicillin, they dominate the picture, are allowed to monopolize any particular advance in knowledge. The author has endeavoured to place each major discovery in its proper setting. For example, in the chapter headed "The History of Antibiotics" all the salient discoveries are discussed, starting with Pasteur's observation in 1877 in which he showed the antagonism between the anthrax bacillus and the common aerobic bacteria, and finishing off with the most recent discoveries of terramycin and erythromycin. Detailed references are made to many outstanding figures who have participated in the development of knowledge in each field, and no limit in time or nationality excludes the mention of individual discoveries. Indeed, even experts in medical research will occasionally be surprised to read of unknown or forgotten observations and discoveries made in the past and in other countries concerning subjects of great current interest.

The book is well worth the attention of both the general reader with some basis of scientific knowledge and of the medical man. After all, it deals with a subject which has transformed human existence throughout the world during the past hundred years, and from this point of view challenges in importance any other scientific advance. Secondly, it is attractively written and can be read with much pleasure. It also gives an opportunity of seeing how well, in

the restricted field of medical research dealt with, British contributions stand in the eyes of a distinguished foreigner. To the British research worker it must afford an unusual experience of seeing some of the fruits of modern medical research in his country receiving adequate appraisal when placed in an international setting. The fact that the book was written primarily for foreign eyes gives it a special value as evidence of the high standing of our medical research. We owe a great debt of gratitude to Dr. Jaramillo-Arango for having undertaken this imaginative tribute to Great Britain, and in return must express our real appreciation of his scholarly and interesting book.

SCIENCE IN CRIMINOLOGY

Medical and Scientific Investigations in the Christie Case

By Dr. Francis E. Camps. Pp. xxiii + 244 + 6 plates. (London : Medical Publications, Ltd., 1953.) 30*s*. net.

RELATIVELY few criminal cases afford the opportunity for any extensive exercise in the forensic sciences. R. *v.* Ruxton and R. *v.* Haigh offered much in reconstruction data for identity, and R. *v.* Dobkin had the added interest of dental detail of exceptional quality and of evidence as to the cause of death. The recent case of R. *v.* Christie has renewed interest in these problems—in methods of ageing, sexing and height estimation in human remains, in the detection of a cause of death after a long interval of time, and the ever-difficult problem of determining the lapse of time since death. It also provided another problem—how to present such evidence at court in the most easily assimilable form : science must be made both reasonable and palatable to lay juries.

This record by Dr. F. E. Camps of the evidence in R. *v.* Christie is not so much his work as that of a team of experts whose specialities—microscopy, analytical chemistry, mycology, dental histology, anatomy, radiology and Dr. Camps's own forensic pathology—combined to forge the links in the evidence presented by the Crown for the prosecution in corroboration of the statements of admission of guilt made by the accused. Like all edited books, it lacks a uniformity of style and reveals both talent and mediocrity in prose-writing. It is in the content of scientific data that its chief attraction lies.

The most polished pieces of work are undoubtedly those of Prof. A. E. W. Miles on the study of the teeth and of Dr. Richard Harrison on the anatomical problems of sexing, ageing and giving stature to the skeletal remains : each is excellently illustrated and well tabulated. Gustafson's modern 'points method' for ageing teeth and of using incremental patterns to assign them to individuals receives some further support, and the superiority of the formulæ of Trotter and Gleser for stature-estimates over the older Rollet, Pearson or even Dupertuis and Hadden formulæ is amply reflected : older tables all showed a tendency to under-estimation. Incidentally, it is to be noted that neither Dr. Camps nor his dental advisers seem to have read the descriptions of 'pink teeth' in the dead by both Thomas Bell in 1829 or of his pupil, the famous Tomes, for they study at some length the nature of the 'new observation', now more than a century old ; little, indeed, is new when one comes to search the literature.

A chapter on the known facts of coal-gas absorption factors by the Gas Board expert, F. C. Smith, tends to elaborate somewhat tediously the standard writings on the subject ; but one must remember that this book is plainly intended for interested lay consumption as well as medical and scientific. Major H. A. Dade records the surprisingly restricted mycological findings of the intact bodies—almost entirely of common and ubiquitous moulds—*Mucor racemosus* Fresen, *Penicillium cyclopium* ; it would have been of interest to have recorded the temperature-ranges for growth of these moulds.

The book is completed by the addition of Christie's three statements, which afforded a great deal of 'testing evidence', and of a short account of the Scott Henderson inquiry which followed public outcry over the prior execution of Evans who had lived with Christie at a material time.

Anyone interested in the application of scientific knowledge to the needs of the law in criminal investigation will find much of interest here : it is a good example of the demands for team-work which occasionally arise in the course of a practice in forensic medicine and criminology, and Medical Publications, Ltd., have made an excellent job of reproduction and illustration on first-class paper. It is not to be recommended to the amateur sleuth, the writer of detective thrillers or the morbidly curious, for it is a serious scientific account of laboratory and field-investigations.

KEITH SIMPSON

POISONOUS PLANTS OF INDIA

Poisonous Plants of India

Vol. 1. By Sir Ram Nath Chopra, Rattan Lall Badhwar and Prof. Sudhamoy Ghosh. (The Indian Council of Agricultural Research : Scientific Monograph No. 17.) Pp. liv + 762. (Delhi : Manager of Publications, 1949.) 30 rupees.

ALTHOUGH the title-page is dated 1949, this book has only recently appeared after a "labour" which has lasted about fourteen years. The manuscript was sent to the press at the beginning of the Second World War ; but owing to vexatious delays due to shortage of paper, and for other reasons, the first volume did not leave the printers' hands until 1949. Shortly after it appeared, the volume was recalled for some correction and has only lately been issued to the public. The welcome which it is sure to receive will be some recompense to the authors for their frustration.

In their preface the authors state that it is their aim to survey the whole field of poisonous plants in India from the botanical, chemical, pharmacological and economic angles. This aim has been achieved ; but it is open to question whether it would not have been better to exclude a great deal of the botanical matter. Botanists who use the book will not be interested in the botany as such, for which they have other sources, and non-botanists will only be interested in the plants and their products.

This is only a trifling criticism ; but the size of the book might have been considerably reduced without sacrificing any of the really important matter in it—which is undoubtedly the account of the poisonous products contained in the tissues of the plants themselves. The information given on this subject is thorough and reasonably up to date, although much work on poisonous drugs found in

Indian plants must have been done since the manuscript of the book went to press fourteen years ago. The authors, in their desire for completeness, even go so far as to describe the symptoms and treatment of persons suffering from poisoning.

Although a great deal of information is given about a large number of species, it is surprising to note the number of plants which are "reported" or "said" to contain poisonous principles, and upon which no work has yet been done. This is a measure of the task which lies before Indian chemists and pharmacognosists during the years to come.

The book is illustrated by a number of line-drawings of very unequal merit. Some of them are reasonably good, while others are quite unworthy of a book of this importance: some are from works fifty years old, while others have come from books published a hundred or even a hundred and fifty years or more ago. A serious defect in the illustrations is that in no instance is there any indication of the size of the parts illustrated, or even what these parts may be, although a number of the blocks contain dissections. If it is thought necessary to have illustrations, then these should be good. The binding is quite inadequate for a book of this weight (4 lb.) and will definitely not stand up to the very frequent occasions on which the volume will be consulted.

The authors are to be congratulated on a really useful book, which for many years to come will be indispensable to all medical and botanical libraries as a work of reference. N. L. Bor

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TURBULENT MOTION OF FLUIDS

The Theory of Homogeneous Turbulence

By Dr. G. K. Batchelor. (Cambridge Monographs on Mechanics and Applied Mathematics.) Pp. xi+197. (Cambridge: At the University Press, 1953.) 25*s*. net.

TO obtain some understanding of the 'turbulent' motion of fluids (a term first used by Kelvin) has been one of the outstanding problems of the physical sciences since 1883, when Osborne Reynolds initiated the subject in a series of brilliant papers. In the succeeding age, when the problems most discussed by physicists were on the atomic and sub-atomic scale, the problem of turbulence remained a notable exception and continued to excite the imaginations of the most eminent students of the physical sciences. Werner Heisenberg, for example, has constantly returned to the subject from his better-known researches in quantum theory, and Rayleigh, Sommerfeld and Kolmogorov all made contributions. Ludwig Prandtl, the creator of the modern dynamics of fluids, who died recently, and his pupil von Kármán, have been important influences at all stages of the work. But perhaps the most single-minded, and successful, of the many warriors assailing the dragon has been G. I. Taylor who, though approaching his seventieth birthday, is still extremely active in the fight. After tackling the problem from many different and valuable points of view, he initiated in 1935 a new approach. Recognizing at last that all the methods based on the conventional ideas of statistical mechanics were doomed to failure, he developed a statistical theory of turbulence founded on the recognition that fluids behave like continua, with the statistical correlation coefficient between the fluid velocities at two nearby points as the fundamental observable. Later he demonstrated the relation of this correlation to the spatial spectrum of turbulence.

The new methods have been applied principally to the particular case of 'homogeneous' turbulence—that is to say, turbulence the statistical properties of which do not vary from point to point. The difficulties of extending them to non-homogeneous turbulence appear formidable; but the qualitative ideas suggested by the statistical theory, and wind-tunnel results, for homogeneous turbulence are already useful in all problems of turbulence. Since the Second World War, progress in homogeneous turbulence has been nowhere so great as in Taylor's own research group in the Cavendish Laboratory, Cambridge, led by G. K. Batchelor and A. A. Townsend. In the circumstances, no one could have been more suitable than Dr. Batchelor for giving a complete account of the present state of knowledge of the subject, and he has succeeded admirably in the book under review. Developing the subject in a logical order, he makes the reader thoroughly familiar with all the detailed correlations and spectra and their simpler, purely kinematical properties, before advancing to the problem of the general dynamics of decay, where one must make use of the fact that each realization of the velocity field satisfies the momentum equation of Stokes and Navier. The need for additional postulates like the 'local similarity' theory of Kolmogorov and the quasi-equilibrium theories of later authors is clearly shown, and these theories are critically explained. The probability distributions of the velocity and its derivatives are described, with physical inferences about the smallest-scale features of turbulence, and the use of the hypothesis that mean products of four velocities are related to mean products of two as for quantities obeying a joint normal distribution law, is illustrated by the calculation of the pressure correlation function. The bibliography is comprehensive, and the general lay-out of the book (the first of a new Cambridge series) makes for easy and pleasant reading. The dedication is "To G. I.".

If, less than two years after the book was completed, the subject has moved on, this is due almost entirely to further work in the Cavendish Laboratory by Dr. Batchelor, Dr. Townsend and their associates. If the book were being re-edited, much less would be said about the general tendency to isotropy of homogeneous turbulence, which seems to be unsubstantiated for the eddies containing most of the turbulent energy. The theory that the joint distribution of velocities becomes normal in the final period of decay, so that different spectral components of the velocity are statistically independent, seems untenable because the different components each decay exponentially in that period, conserving whatever statistical dependence they may already have. Again, the theory of the 'permanence of big eddies' is currently being questioned. Dr. I. Proudman has calculated the sound field which isotropic turbulence generates.

All the time, in fact, the extent of our pitifully small understanding of turbulent motion is increasing. If all students of the subject make themselves thoroughly familiar with the material of Dr. Batchelor's book, so that they obtain a clear idea of the established knowledge without being encouraged to gloss over any real difficulties or unsimplifiable intricacies, then one may expect future progress to become faster still. M. J. Lighthill

Electrodynamics

(Lectures on Theoretical Physics, Vol. 3.) By Arnold Sommerfeld. Translated by Edward G. Ramberg. Pp. xiii+371. (New York: Academic Press, Inc., 1952.) 6.80 dollars.

FOUR of the six volumes in the German edition of Prof. A. Sommerfeld's "Lectures on Theoretical Physics" have been reviewed by Prof. R. E. Peierls (*Nature*, **168**, 887 (1951); also **170**, 684 (1952)), who regarded them as representing "an almost perfect choice of topics for a basic course on theoretical physics" and eagerly awaited an English translation of the series. The translation by E. G. Ramberg of Vol. 3, "Electrodynamics", fully justifies Prof. Peierls's enthusiastic comments.

This book is divided into four main parts. Maxwell's equations in vectorial integral form are the starting-point of the theory in Part 1, and the electromagnetic phenomena are derived from them systematically by deduction in Part 2, which constitutes the main portion of the volume. Special relativity and the Lorentz theory of the electron are covered fully in Part 3, and the electrodynamics of moving media is developed in Part 4. The book concludes with a selection of problems, together with answers and very helpful comments. The subject is presented in such a manner as to stimulate thought, many of the topics being originally developed by Sommerfeld and his school at Munich. The parallel nature of the magnetic induction B and the electric intensity E is stressed; they are classified as "entities of intensity", whereas the electric displacement D and the magnetic intensity H are "entities of quantity".

It is unfortunate that the book is unsuitable for use as a text-book in a third-year honours course in physics, since several topics usually associated with the subject are found in the other volumes of the series, to which many references are made. The book will, however, form a very useful reference book for advanced students.

Journey into Wonder

By N. J. Berrill. Pp. 320. (London: Victor Gollancz, Ltd., 1953.) 13*s*. 6*d*. net.

"THE power of thought is not knowledge alone, it is the thrust of intellect as it selects this and that feature from the chaotic accumulation and builds them swiftly into a coherent pattern." So writes Prof. N. J. Berrill when viewing the limitations as a chronicler of the seventeenth-century adventurer and explorer, William Dampier. The ability to select and build from a vast accumulation of knowledge is clearly possessed by Prof. Berrill himself to a marked degree. From the accounts of the voyages of Columbus, the medieval mystic searching for the Indes and the Garden of Eden, to the harassing journeys in the Antarctic of Shackleton and Scott, he has constructed a most coherent and absorbing account of the natural history of the world's great voyages of exploration. Not only are the discoveries of the naturalist explorers such as Darwin and Humboldt, or the Fosters who accompanied Captain Cook, included, but also many interesting though unexpected observations by the buccaneers, Drake and John and Richard Hawkins.

This book, however, is much more than a judicious selection of other men's writings. It is a synthesis, containing many intriguing speculations based on the observations made by these explorers. Prof. Berrill throws new light, for example, on the probable location of Columbus's first landing after crossing the Atlantic, gives a masterly summary of the evidence for the origins of the Polynesian race from the east and so dismisses the theory which inspired the remarkable Kon Tiki expedition, while one of his most interesting discussions is on the origin and evolution of penguins. Prof. Berrill writes with a light hand and a puckish humour which makes his "Journey into Wonder" quite wonderful.

ALAN J. BROOK

Report of the Thirteenth International Horticultural Congress 1952; London, 8–15 September

Vol. 1: Pp. xv+576+39 plates. Vol. 2: Pp. viii+577–1297+plates 40–100. (London: The Royal Horticultural Society, 1953.) 42*s*. the set.

THE Thirteenth International Horticultural Congress was held in London during September 8–15, 1952, and some of the principal contributions were reviewed in these columns shortly after the Congress (*Nature*, **170**, 647; 1952). The full text of all the papers, which has now been published, makes a valuable symposium on modern horticultural problems, both practical and scientific.

Much space is devoted to the international code of nomenclature for cultivated plants, which is printed in full. The text of ten general lectures makes a valuable summary for those who have but limited time to follow the latest developments. For readers who require greater detail, there are sections on fruit growing, vegetable growing, ornamental plant growing, plant diseases and purity of stocks, on plant breeding, environmental control and on seeds. Tropical and sub-tropical horticulture is given a special section, while special symposia on citrus problems and on botanic gardens meet very specialized needs.

The hundred half-tone plates in the two volumes are of excellent quality, and very numerous line-diagrams enrich the text. The papers are published in English, French or German, but all have summaries in English and French. Scientific developments in horticulture are now taking place with such rapidity that it is scarcely possible for one individual to review, by normal methods, more than a part. An international congress brings an outstanding opportunity to review the whole, to digest the knowledge and bring it within the range of the teacher or grower, and to take stock of it. The volumes now published are worthy of the occasion.

JOHN GRAINGER

Roger Bacon in Life and Legend

By E. Westacott. Pp. 140. (London: Rockliff Publishing Corporation, Ltd., 1953.) 10*s*. 6*d*. net.

A SHORT life of Roger Bacon is an undoubted need; but the present work will not do much to fill it. The author has tried to give a straightforward account and has no axe to grind; but he would seem to be unqualified to attempt the far from easy task of presenting the facts of Bacon's life and assessing the value of his work. The book is a derivative one and is largely based on the ninety-year-old biography of Emile Charles, together with some material derived from other works of varying status. The recent great developments in the study of medieval science have passed the author by. This would matter less if the work were clearly presented; but in fact it is inconsequent and confused, with not a few mis-spellings of Latin titles and proper names.

F. SHERWOOD TAYLOR

JUBILEE OF THE UNIVERSITY OF LEEDS

By Prof. D. G. CHRISTOPHERSON, O.B.E.

THE University of Leeds received its Royal Charter on April 25, 1904. Before that date, as the Yorkshire College, it had since 1887 been one of the three constituent colleges of the Victoria University, the other two being Owens College, Manchester, and University College, Liverpool.

At the time, there were some doubts whether the College, which dated its original foundations only from 1874, would be able to stand on its own feet as an independent university. The Yorkshire College was the last of the three to present a petition for a Royal Charter, and the delay is a measure of the relative unwillingness of the College to cut adrift from the parent University.

In the upshot, from the beginning, these fears appear to have been largely groundless. Progress, although limited by lack of funds at least until the relative bounty of the years following the Second World War, has been steady. In 1904, there were twenty-seven professors, and approximately the same number of Departments. After the First World War, this number had grown to thirty-three. It is at present sixty-six. Student numbers have increased in about the same proportion. In 1949, the year in which the post-war bulge reached its maximum, there were 3,336 students, and it was supposed that when the demand from the ex-service men had been met, there would be a substantial recession. This has not happened, the number this year being 3,267. University building has also proceeded steadily: the immediate pre-war years saw the erection of the Brotherton Library, and the University Union, both now substantially overcrowded but still among the best of their kind in the civic universities of Britain. Since the War, the large and handsome Parkinson building has been completed, and a spacious new refectory which it is hoped will do much to relieve the strain upon the Union and to assist the social and cultural life of the University is nearing completion.

Developments on this scale bring their own problems, not all of which are financial. The founders of civic universities and colleges in recent times have usually had to choose at the outset between two alternative policies. They could select a site near the centre of their city, which would have great practical advantages from the point of view of convenience of access, and perhaps also, less tangibly, in fostering a greater feeling of interdependence and mutual understanding between the university and the city. Alternatively, the university could be put well outside the built-up area, where room for expansion could be easily acquired when needed, where in many cases the conditions of life were pleasanter, and where a sense of detachment could be more easily cultivated. True, a larger share of resources would then have to be devoted to building halls of residence for students; but many would take the view that this is in itself an additional point in favour of a policy of building outside the city. The founders of the Yorkshire College may have felt that in placing the College on the edge of what was then the continuously built-up area they were adopting the best compromise between these two policies. In practice, due to the enormous growth of the city over the past seventy years, they were following the former. Their successors have succeeded to a striking extent in resisting the centrifugal tendency which a crowded site invariably produces. The University has been kept together, but at the price of severe congestion on the present site. Looking forward into the future, it can be discerned that after another fifty years much obsolescent housing will have vanished, the pall of industrial smoke which all too often covers the city will have been dispelled, and the University will be found to occupy the ideal situation, near enough to the centre to form a real part of civic life and society, compact enough for its essential unity to be apparent in every Department and to every student, and yet with enough free space for the various buildings to be reasonably sited without undue congestion. In the meantime, although no opportunity of pushing back the frontiers has been missed, progress towards adequate living-space has often seemed slow.

The Jubilee celebrations will no doubt be principally an expression of confidence in the future; but they will not be without a note of pride in the past. There is no space in this article to refer to many of the distinguished men who at various times have contributed to the academic life of the University. Exception can be made for three names only. In the years before the First World War, it was at Leeds that the Braggs achieved their classical researches on the X-ray spectrometer; in a long tenure of the chair of chemistry, Smithells built up a Department of Chemistry which has remained outstanding through the whole fifty years of the University's life; as vice-chancellor for the years 1911–23, Sir Michael Sadler did so much to broaden the purpose of the modern universities, and to achieve a synthesis of the traditions of the ancient universities and the dynamism of the new, that he can be said to have exercised a decisive influence on the history of university education in Great Britain.

Leeds has always been strong in the field of applied science. The Yorkshire College had Departments of Agriculture, Engineering, Textile Industries, Colour Chemistry, Leather Industries and Mining. The Department of Coal Gas and Fuel Industries was added in 1906, and now includes Chemical Engineering and Metallurgy. The link between these Departments and the Departments of Pure Science is very strong. Almost all technological students spend a large part of their time in the first two years of their course in the appropriate Science or Mathematics Departments, and all courses are controlled by a joint Board of the Faculties of Science and Technology. In this field, to which so much public attention has been given in recent years, the University of Leeds feels that it has an especial, perhaps a unique, experience.

The long history of technology at Leeds, however, carries with it one drawback—that all the technological departments, with the exception of the Department of Mining, are now housed in relatively old quarters, several of them in the original buildings of the Yorkshire College. As a first step in overcoming this difficulty, the Department of Textile Industries, with very substantial financial support from the industry, is going ahead with the erection of a rayon technology building. The next major item in the

development programme envisages the beginning of a new block to the north of the present site, which will provide new quarters first for the Coal Gas and Fuel Industries Department and afterwards for the engineering departments.

Fifty years is a short time in the life of a university. Compared with the slow evolution which went on through the preceding centuries, the changes which have taken place in the twentieth century are extraordinary. (But it must be borne in mind that much larger institutions have been evolved in the same time in the United States.) The question naturally arises as to whether the foundation of a university is simply a matter of material resources—money must be spent, and buildings erected, and a university will be found to have been created—or whether there is something vegetable about its growth. Many able and intelligent men—or perhaps many generations of able and intelligent men—must give their life's work before the accumulation of inherited wisdom and experience implied in the title of university can be built up. What is unseen, in academic standards, in understanding of the needs of undergraduates, in the immensely important but unpublicized field of relations between schools and universities, is more important than what can be seen and counted in buildings and departments. It may be that Leeds, in common with other relatively recent foundations, has still to complete its education in these subjects. But in fifty sessions, awareness of these intangible factors has grown continuously, and the University looks forward to its next half-century with a confidence based not only on the substantial material resources which have been built up, but also on an ever clearer conception of the purpose of a university and its place in contemporary society.

CRYSTALLINE CYTOCHROME b_2 AND LACTIC DEHYDROGENASE OF YEAST

By C. A. APPLEBY and Dr. R. K. MORTON

Department of Biochemistry, University of Melbourne, Australia

FOLLOWING the re-discovery of cytochromes by Keilin[1], a number of different members of this important group of intra-cellular hæm-proteins has been described on the basis of their absorption spectra. Particular interest is attached to cytochromes of the *b* group, that is, cytochromes *b*, b_1, b_2 and b_3, some of which appear to be intimately associated with certain enzyme systems. Thus, cytochrome *b* appears to be closely linked to the succinic dehydrogenase system of animal tissues, plants and certain bacteria, and it has been claimed that this cytochrome is identical with succinic dehydrogenase in *Corynebacterium diphtheriae*[2]. Dixon and co-workers[3–5], in classical studies of the lactic dehydrogenase system of yeast, found that a hæmprotein which they called cytochrome b_2 was an essential component of this enzyme system. Although considerable purification was achieved, marked instability of the most active preparations prevented conclusive demonstration as to whether the cytochrome was the dehydrogenase (that is, the enzyme which reacts *directly* with the substrate) or an essential intermediate carrier acting between lactate and the electron acceptor (methylene blue in these studies). Yeast lactic dehydrogenase is one of a small but important group of 'cytochrome *c*-linked' dehydrogenases. Since the relationship between cytochrome b_2 and lactic dehydrogenase has considerable bearing on views as to the nature of the enzymes of this group, we have re-examined this enzyme system of baker's yeast.

Lactic dehydrogenase activity has been determined spectrophotometrically when using potassium ferricyanide or cytochrome *c* as electron acceptors. When measuring the rate of reduction of methylene blue, we have used the Thunberg tube method[6]. Extensive preliminary studies confirmed the observations of Dixon and associates[5] that cytochrome b_2 accompanied the lactic dehydrogenase activity throughout many different purification procedures. Moreover, the cytochrome b_2 was rapidly and completely reduced by the addition of lactate to active enzyme preparations. In preparations which had lost most of their dehydrogenase activity following storage, the cytochrome component was still completely, although slowly, reduced by lactate. The cytochrome b_2 of inactive enzyme preparations was no longer reducible by lactate, although completely reduced by dithionite. Thus, it seemed likely that the cytochrome b_2 was not involved in the *direct* reaction with lactate. Attention was therefore given to methods for complete purification of the enzyme system.

By treatment of the yeast with *n*-butanol, essentially by the method previously described by the senior author[7], the enzyme was dissociated from accompanying lipid material which is probably of mitochondrial origin. Subsequent purification procedures, which will be described in detail elsewhere, yielded clear extracts containing the dehydrogenase activity as well as cytochromes b_2 and *c*. From such extracts the enzyme was eventually separated as well-formed crystals. The first crystals obtained are shown in Fig. 1. These were allowed to develop slowly and are therefore relatively much larger than those which were grown rapidly from recrystallized material and which are also illustrated. The crystals show only weak anisotropy. They are readily soluble in suitable dilute buffers at neutral *p*H values.

Enzymic Properties of Crystalline Lactic Dehydrogenase

The best crystalline preparations have an activity of approximately 7,000 units (μmoles ferricyanide reduced/hr./mgm. dry weight) at 20° C. and at optimal *p*H (8·0). With methylene blue at *p*H 5·2, using a reduction time of approximately 10 sec., the same preparations have activities of 740 units (μmoles methylene blue reduced/hr./mgm. dry weight) at 20° and 2,100 units at 38° C. The corresponding Q_{MB} values (as defined by Bach *et al.*[5]) are 16,500 and 47,000 at 20° and 38° C., respectively, and hence the crystalline enzyme is about fifteen times as active as the best preparations (Q_{MB} 3,000 at 38°) obtained by the earlier workers[5].

Bach *et al.*[5] observed that crude extracts containing the enzyme rapidly reduced cytochrome *c*, and determined the rate of reduction of cytochrome *c* manometrically in the presence of excess cytochrome oxidase. During the course of purification of the enzyme, they found that the rate of reduction of cytochrome *c* became considerably less than that of

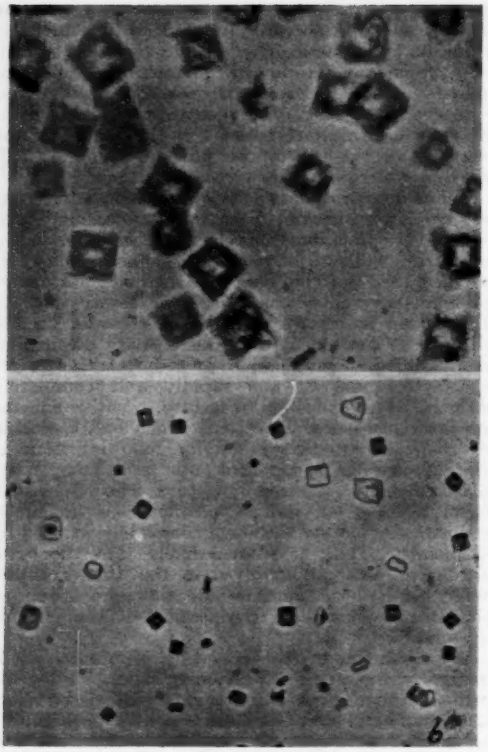

Fig. 1. Crystalline cytochrome b_2 from baker's yeast. The initial crystals are shown in the upper photograph (*a*) and twice recrystallized material in the lower (*b*). Both photographs taken using phase-contrast. × 260

methylene blue. Nevertheless, spectroscopic observation showed that their purest preparations could still reduce cytochrome *c*.

By direct (spectrophotometric) measurement of the rate of cytochrome *c* reduction during the course of purification, we have found that the rate of reduction of cytochrome *c* is undiminished as compared with reduction of both ferricyanide and methylene blue. The same proportionality with the three different electron acceptors is found in enzyme which has been twice recrystallized. The best preparations have an activity of approximately 1,800 units (μmoles cytochrome *c* reduced/hr./mgm. dry weight) at 20° C. and at *p*H 7·0. The reduction of a molecule of cytochrome *c* or of ferricyanide involves only a single electron transfer, whereas reduction of a molecule of methylene blue involves two electrons. Hence it is seen that, at 20° C., the rates of reduction of cytochrome *c* (1,800 units) and of methylene blue (740 units) are of similar order of magnitude but about four to five times less than that of ferricyanide (7,000 units).

The reduction of cytochrome *c* by the crystalline enzyme was not inhibited by 'Antimycin *A*' ($1·5 \times 10^{-4}$ *M*), which specifically inhibits the reduction of cytochrome *c* by the succinic dehydrogenase system of animal tissue homogenates[7]. However, a partially purified preparation of the lactic dehydrogenase was 90 per cent inhibited by *p*-chloromercuribenzoate (10^{-2} *M*) when tested with ferricyanide as electron acceptor. This suggests that certain —SH groups are necessary for enzymic activity, as in the case of succinic dehydrogenase[8].

Physical Properties of Crystalline Lactic Dehydrogenase

Crystals of the enzyme are distinctly pink in colour, while concentrated solutions are brown-coloured when oxidized and coral-pink when reduced with either lactate or dithionite. The oxidized enzyme shows little or no absorption in the visible region of the spectrum, but the reduced enzyme shows strong absorption bands at 556·5 mμ (α-band) and 525 mμ (β-band) as determined using a Hartridge reversion spectroscope. These bands correspond with those previously described for cytochrome b_2 by Dixon and co-workers[5]. Both absorption bands were intensified by freezing in liquid air as described by Keilin and Hartree[9], and the α-band was shifted to 555·2 mμ, while there was no observable change in the position of the β-band. The crystalline enzyme appears to be completely free from cytochrome *c*.

The absorption spectrum of the crystalline enzyme as determined in the Beckman spectrophotometer is shown in Fig. 2. The oxidized enzyme (curve *A*) shows a parahæmatin-type spectrum, with general absorption in the region of 550 mμ and with bands at 413 mμ (Soret) and 359 mμ. There is a pronounced absorption band in the ultra-violet region, with peaks at 263 mμ and 257 mμ. Curve *B* shows the spectrum of the enzyme reduced with lactate. The positions of the absorption bands are as follows: α, 557 mμ; β, 528 mμ; γ (or Soret), 424 mμ; δ, 330 mμ. The absorption in the ultra-violet region is similar to that of the oxidized enzyme. These curves may be compared directly with those of cytochrome *c* as obtained by Margoliash (see Keilin and Slater[1]) and of cytochrome *f* (Davenport and Hill[10]), both of which have been highly purified but neither of which has so far been obtained in a crystalline form. It is clear, therefore, that lactic dehydrogenase activity and cytochrome b_2 are intimately associated in the crystals. Moreover, in confirmation of the observations of Dixon and co-workers[5], there is a direct relationship between the concentration of cytochrome b_2 and lactic dehydrogenase activity as determined in several different crystalline preparations and after recrystallization.

Prosthetic Groups of Lactic Dehydrogenase

The absorption spectrum of the pyridine hæmochromogen of the crystalline enzyme was determined in the Beckman spectrophotometer and found to be identical with that of the pyridine hæmochromogen from a pure sample of hæmin. This confirms the finding of Dixon and associates[5] that protohæm is the hæm group of cytochrome b_2, and protohæm must also now be considered as a prosthetic group of lactic dehydrogenase.

A sample of enzyme which had been twice recrystallized was denatured by heating to 100° for 2 min. at *p*H 6·8. An equal weight of ammonium sulphate was added, and the brown protein precipitate was removed by high-speed centrifuging. The clear supernatant was a pure green colour and showed a strong fluorescence typical of riboflavin. The flavin was extracted into phenol, transferred to water, and then compared with authentic samples of flavin adenine dinucleotide, riboflavin-5′-phosphate (flavin mononucleotide) and riboflavin, using paper

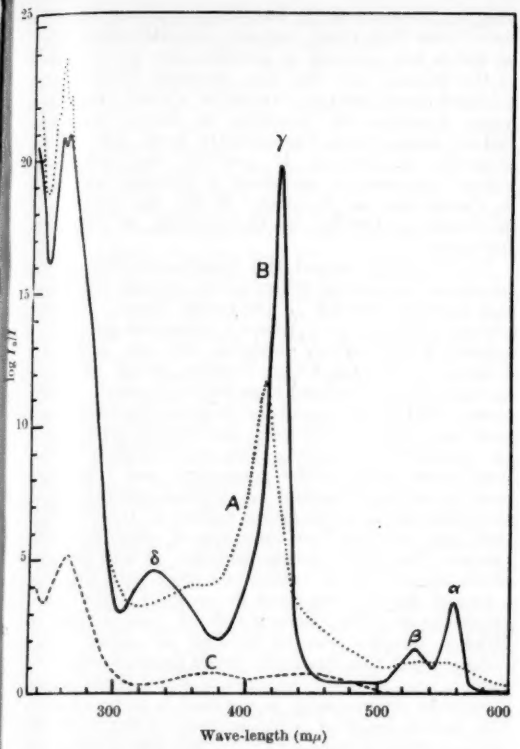

Fig. 2. Absorption spectrum of crystalline cytochrome b_2. Curve *A*, oxidized; curve *B*, reduced with lactate; curve *C*, supernatant obtained by heat denaturation of enzyme. Curves are given at cytochrome concentration equivalent to 10^{-4} *M*-hæmin. α, β, γ and δ denote absorption bands of the reduced cytochrome

chromatography. In two different solvent systems (*n*-butanol–acetic acid–water, and pyridine–*n*-propanol–water)[11], the unknown flavin moved as flavin mononucleotide. There was no flavin adenine dinucleotide in the enzyme extract. It is therefore tentatively concluded that the flavin is flavin mononucleotide.

The absorption spectrum of the flavin obtained by heat-denaturation of the enzyme, at the same concentration as for curves *A* and *B*, is shown in Fig. 2 as curve *C*. The spectrum is identical with that of flavin mononucleotide except for somewhat increased absorption in the ultra-violet region, probably due to some protein denaturation products. The contribution of this flavin to the absorption of the enzyme in the region 300–600 mμ is apparently small, since the oxidized enzyme (curve *A*) shows no clear indication of absorption in this region which could be attributed unequivocally to the presence of the flavin. It is possible that the decreased absorption of the reduced enzyme at 445 and 373 mμ (the absorption maxima of flavin mononucleotide) may be partly due to the reduction of the flavin by lactate, but the difference spectrum (oxidized minus reduced enzyme) is not the spectrum of flavin mononucleotide. The most noticeable contribution of the flavin (which, like the mononucleotide, has a peak at 266 mμ) to the absorption of the enzyme is undoubtedly in the ultra-violet region. The apparently small influence of the flavin on the spectrum of the oxidized enzyme in the region 300–600 mμ may possibly be produced by modification of the flavin absorption due to combination with the protein.

The flavin group is completely bound to the enzyme, and normally none is dissociated, since freshly prepared solutions of the crystals show no flavin fluorescence. However, this always develops on storage at 0° and is increased by dialysis. The appearance of fluorescence due to free flavin is associated with decline of enzymic activity, and there is a relationship between the amount of fluorescence, as judged by visual examination, and the extent of decline in activity. It is therefore apparent that the flavin is directly concerned in the activity of the enzyme, and hence flavin mononucleotide must be regarded as a prosthetic group.

Nature of Lactic Dehydrogenase

Electrophoretic examination of twice-crystallized material has been carried out in a Tiselius-type apparatus, using 1 per cent protein in phosphate–lactate buffer, *p*H 7·05, ionic strength 0·25. One component, in very small amount, moved rapidly away from the main material. This was afterwards identified as free flavin, which had apparently dissociated during dialysis (40 hr.), but had not attained equilibrium with the buffer system. The protein component, however, appeared as a single peak, which remained symmetrical for more than three hours, although some asymmetry developed after five hours. This preliminary result, therefore, strongly supports other evidence that the crystalline enzyme consists of a single protein.

While further studies of the physical and chemical properties of the crystalline material are in progress, the evidence so far available strongly indicates that yeast lactic dehydrogenase is a single protein with two different prosthetic groups. Despite many attempts, we have not so far been able to isolate a separate, active flavoprotein from cytochrome b_2. The possibility that the flavin group is associated with an adsorbed contaminant is further excluded by the fact that, while cytochrome *c* and other inactive material remain in the supernatant at the initial crystallization step, the flavin as well as the cytochrome b_2 is almost wholly removed from the mother liquor with the crystals. The constant proportion of one hæm group to one flavin group, as found in the initial crystalline product and after two further recrystallizations, also indicates that both groups are associated with the one protein. Moreover, the total purification, as compared with the initial yeast on a dry-weight basis, is at least 7,000-fold, while a tenfold purification is achieved in the crystallization step. Despite this considerable evidence in favour of homogeneity of the enzyme system, we are continuing efforts to resolve it into more than one active protein.

In the case of a single protein with two prosthetic groups, it becomes somewhat artificial to distinguish between the 'dehydrogenase' and the 'electron-carrier'. However, the two groups presumably are concerned with different functions, and we incline to the view that the flavin mononucleotide group, rather than the protohæmin, acts as the *direct* acceptor of electrons from lactate. Dissociation of the flavin mononucleotide group appears to be irreversible, and partial dissociation or interference with this group would account for decline or loss of

ability to reduce the protohæmin by lactate, whereas it would still be reducible by dithionite. 'Dehydrogenase' activity thus appears to be dependent on the flavin group, and 'electron-transfer' on the protohæm group. It is noteworthy that the cytochrome b_2 of inactive, oxidized enzyme is completely reduced by the addition of lactate together with a small amount of active lactic dehydrogenase.

Yeast lactic dehydrogenase is the first of the 'cytochrome *c*-linked' dehydrogenases to be highly purified. It is of especial interest in that it is itself a cytochrome, being the first of the *b* group to be considerably purified and the first cytochrome to be obtained in crystalline form. It appears to belong to a new class of enzymes not hitherto described, and may well be unique. However, evidence recently obtained with partially purified heart-muscle succinic dehydrogenase[6] also indicates that this enzyme is dependent for activity upon a flavin group, and in this respect resembles yeast lactic dehydrogenase. It would seem quite possible that the other known 'cytochrome *c*-linked' dehydrogenases, namely, mitochondrial α-glycerophosphate dehydrogenase of skeletal muscle, liver choline dehydrogenase, and the malic dehydrogenase systems of certain yeasts and bacteria, are similar flavoproteins.

We wish to thank Mr. Barrett, of H. Hudson and Co. Pty., Ltd., for his helpful co-operation and for the generous gift of yeast for this investigation. We are grateful to Mr. J. Pye, of the Walter and Eliza Hall Institute for Medical Research, for carrying out the electrophoretic examination of the enzyme for us. Dr. M. Dixon suggested this problem to the senior author (R. K. M.), who commenced the investigation at the School of Biochemistry, University of Cambridge, and has continued it at the University of Melbourne. One of us (C. A. A.) is seconded from the Division of Plant Industry, Commonwealth Scientific and Industrial Research Organization, Canberra. [Jan. 21.

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PRESERVATION OF FOODS WITH IONIZING RADIATIONS

POWERFUL sources of ionizing radiations have become increasingly available during the past ten years, and a corresponding interest has developed in their use for industrial purposes. Among the possibilities which have received some attention is the utilization of the lethal effects of these radiations for killing micro-organisms in food, thus reducing or eliminating the primary cause of most types of spoilage. If this could be effected without materially damaging the food, and at economical cost, the process could represent a marked advance over existing procedures. It has, however, been clear for some time that many unusual considerations must be taken into account in assessing the potentialities of the method and that the necessary experimental evidence is only partially available, if at all. Although many features are therefore in doubt, sufficient factual information has recently been felt to be available in Britain to provide the basis for a short symposium, and such a meeting was held in Cambridge on February 10 by the Food and Microbiology Groups of the Society of Chemical Industry.

Dr. W. Wild opened the symposium with a discussion of the general properties of ionizing radiations and possible methods of producing them. Suitable sources fall into two groups: electrical generators delivering high-speed electrons or, less probably, X-rays; and radioactive sources giving electrons (β-rays) or electromagnetic radiation (γ-rays). Generators would be the more feasible source for large-scale work during the next decade, and several types might be considered, including Van de Graaff, resonant transformer and impulse generators, and travelling-wave linear accelerators. A typical generator now available has an accelerating voltage of three million volts and delivers four kilowatts of electron beam-power. This could sterilize samples, of unit density, about an inch thick (irradiating from both sides) at a rate of about a thousand lb. an hour; the cost is estimated at a few pence per lb. of treated product. Thicker samples can be treated by using higher voltage; but this must not exceed approximately ten million volts (sample thickness of about three inches) if induced radioactivity in the food is to be avoided. The British-designed linear accelerator seems to offer most promise of reliable working and also of obtaining high voltages without undue increase in capital cost; models giving several kilowatts of beam power seem feasible, although present models have only a relatively low power-output (500–800 W. at 4 million volts).

The limited penetration of electrons is an obvious disadvantage for many applications, and the much more penetrating γ-rays would often be preferred even though thick shielding would be needed to protect factory personnel from the radiation. Two main sources can be considered: the spent reactor fuel rods in their initial 'cooling' period; and the residues (fission products) which remain after chemical processing of the fuel rods. A medium-sized nuclear power station could probably deliver a million reps to a thousand tons of food a day from the former source; little special provision would be needed except a device for presenting the food to the radiation, provided that the food could be brought to, or near to, the power station. Fission products, on the other hand, could be processed into transportable sources for use in more distant factories, assuming that methods could be developed for moving, safely, the megacurie sources required. It is still too early to estimate, reliably, the probable cost of fission-product radiation, although costs comparable with those for existing electron generators seem possible. The technique of preparing sources has yet to be developed, however, and the potential demand is unknown. It would therefore be preferable at this stage to adopt the alternative approach, as in the United States, of asking industry to indicate what would be regarded as acceptable processing costs. Dr. Wild concluded by saying that further details are available in several publications and that either

he or his colleagues at Harwell would be glad to discuss them with anyone interested.

Dr. L. H. Gray then outlined present views of the biological effects of irradiation. The primary process is a physical act of energy absorption which leads to the excitation and ionization of individual atoms. The biological damage which results, however, takes several forms, among the most important of which is a loss of the property of cell reproduction; this is eventually followed by cell death or in some circumstances by differentiation. Other less-damaged cells show a partial recovery from the effects of irradiation; but these are generally overgrown by normal or only slightly injured cells. A small proportion of the cells which survive will also usually be found to have undergone a mutation. Tissue cells show a type of response which should particularly be noted, for they give rise to tumours. This carcinogenic effect of irradiation, which is little understood, deserves very serious consideration in connexion with the sterilization of foodstuffs. In studying the cause of these effects it has been found that direct tests of metabolic activity such as respiration, glycolysis and adenosine triphosphate synthesis show little change even with quite high doses. Many important enzyme systems are therefore not damaged; but metabolic steps are undoubtedly involved in the development of radiobiological damage.

The probability of any small unit of biological organization being directly ionized is quite small until the dose reaches levels of the order of millions of r.e.p.; but there is a much greater probability of attack by free radicals arising in the aqueous phase. Various factors such as radiation quality and oxygen tension can be shown to affect indirect chemical reactions of this type in a manner which strikingly parallels their effect on biological response, and it is now believed that much radiobiological damage is due to the action of free radicals arising immediately from water or of more stable radicals to which they give rise.

The last two papers of the symposium were concerned more with the practical aspects of the effects of irradiation on typical food systems. A paper on the effects on micro-organisms by Drs. R. S. Hannan, Marguerite I. Davis and M. Ingram was read in two parts by the first two authors. Dr. Davis first described the general features of the response of micro-organisms. The most important effect is that, with sufficiently large doses of irradiation, the organisms fail to multiply, and this can be accounted for broadly in terms of an ionization having occurred in a sensitive region of the cell. It has recently become apparent, however, that the lethal effect of a given dose can be modified by changes in the environment of the organism, such as removal of oxygen, addition of several types of protective compound, removal of water or change of temperature. These effects are of great practical importance, since they indicate that the dose required to inactivate micro-organisms in a food product will depend to some extent on the nature of that food and the method of processing.

Dr. Hannan then showed how the lethal effects might be utilized. Several workers have shown that even the most resistant spores, in broth suspension, can be inactivated by doses of the order of 2×10^6 r.e.p., that is, equivalent to a temperature rise of 4 deg. C. Yeasts, moulds and vegetative bacteria are somewhat more sensitive. Sterilization without heating is therefore possible and is the most interesting potential application. Much work is still needed with practical food systems; but it seems possible that doses up to 3×10^6 r.e.p. may eventually be found to be necessary, partly to allow for individual circumstances which might protect the micro-organisms and partly to ensure, with a high degree of certainty, that all samples in a given batch will be sterile. Much lower dose-levels might find practical use, however. Approximately 5×10^5 r.e.p., for example, inactivates many of the micro-organisms in most foods and delays the onset of microbial spoilage; harmful vegetative organisms are also destroyed. Even lower doses of $2–5 \times 10^4$ r.e.p. have been used to break the reproduction cycle of insects in foods (for example, *Trichina* larvæ or wheat weevil). Very large doses, however, probably of the order of $1–5 \times 10^5$ r.e.p., are needed to inactivate viruses.

Dr. Hannan then went on to describe the effects of irradiation on the foods themselves. The greatest obstacle to the application of the process, apart from economic considerations, is the fact that chemical damage to the food itself can seldom be ignored. Prohibitive changes in colour, odour and flavour frequently occur, and the study of these effects is still largely in the empirical stage. It is clear, however, that the chemical change is limited in total extent (of the order of a few μmoles/gm. for a sterilizing dose) and is of two main types: the indirect effects in the aqueous phase, described by Dr. Gray, and a complex series of effects in the lipids. The most obvious changes appear to be oxidative. Freezing before irradiation, removal of oxygen and adding 'protective' compounds materially decrease many of these effects, and the suppression of damage with most products at high dose-levels usually depends on the feasibility of using auxiliary processes of this type.

Raw beef irradiated with a sterilizing dose of 2×10^6 r.e.p., for example, develops a strong, unpleasant, irradiation odour and flavour; but these can virtually be eliminated by de-aeration and deep-freezing before irradiation. This would be difficult to apply on an industrial scale, however, and an alternative procedure of adding protective compounds, including ascorbic acid, which dispenses with the freezing operation, would be commercially more attractive. Unfortunately, however, this only partially controls the radiation damage, and the chemical basis of the protective action is, moreover, far from clear. In a brief survey of the irradiation of a range of foods, Dr. Hannan pointed out that most products of animal origin develop typical 'irradiation' odours and flavours, and require similar protective techniques. This is especially true with dairy products, where the flavours are usually very strong. Many processed and cured meats show relatively little flavour change, however, presumably owing to the protective effect of nitrite and fat antioxidants which are usually present. The treatment of fruits and vegetables raises many difficulties, if only from the action, during storage, of enzymes which are not usually inactivated by irradiation. The storage life of many other types of product is, in fact, limited by chemical and enzymic change during storage. Even at dose-levels of the order of 5×10^5 r.e.p. which might be used for retarding microbial spoilage, 'irradiation' flavours are usually marked, and it is not until 10^5 r.e.p. or even less that the threshold of sensory detectability is reached with many products. Little change would usually be detectable with doses of the order of 2×10^4 r.e.p.

which might be used for disinfestation; but even at this dose-level it is necessary to consider carefully how far irradiated foods can be considered suitable for human consumption. Desirable constituents such as vitamins might be partially destroyed; but the greater possible danger is that harmful compounds might be formed. There has been no positive demonstration that this is a significant danger; but a very great deal of evidence would be required before it could be discounted.

An active discussion followed, most of which was concerned with matters of detail; but one point is noteworthy: the view was expressed that the basis for assessing the potential toxicity of irradiated food need not necessarily be more rigorous than that applied to other methods of processing. It would be illogical to demand the complete characterization of every chemical change irradiation might produce, since this is not even known for kitchen cooking.

No positive conclusion can be drawn from the proceedings of this symposium except that the process is highly novel and of obvious interest. There is, however, no firm indication that it would be commercially applicable in Britain in the near future in any of its many forms. Even if the effects of radiation on foods and micro-organisms were to be clarified, there would still be many problems in assessing the economic value of the process and translating the laboratory results to the factory. The present position is therefore still one of seeking products and methods of processing which offer such unmistakable advantage that the developmental problems can be attacked and overcome. Suitable products may well be found more easily in the pharmaceutical than in the food industry.

R. S. Hannan

OBITUARIES

Sir Nelson Johnson, K.C.B.

Nelson King Johnson was born on March 11, 1892. He was educated at Canterbury, his native city, and at the Royal College of Science, London, of which he was an associate. After taking his degree he worked for a time on astrophysics under Prof. A. Fowler. In 1913 he went to the observatory at Sidmouth founded by Sir Norman Lockyer for research in solar physics. When war came in 1914 he joined the Royal Flying Corps and became one of the early night-flying pilots. On a night of bad visibility he had a serious crash and this, combined no doubt with the influence of W. J. S. Lockyer, meteorologist as well as solar physicist, led Johnson to the Meteorological Office at the end of the First World War. In 1921 he was put in charge of the new meteorological section of the Chemical Defence Research Establishment, from which so much of our knowledge of the lower layers of the atmosphere has since come.

Johnson himself carried out two investigations of the temperature at different levels by continuous records day and night, for three years at Porton and for five years at Leafield, where he had the assistance of G. S. P. Heywood. No such comprehensive investigation of this problem had previously been undertaken; and no one familiar with the difficulty of eliminating the many sources of error in the continuous measurement, in all conditions of weather, of atmospheric temperature at levels up to 300 ft., can but admire the way Johnson surmounted the difficulty. A very full analysis and discussion of the records was published in the Geophysical Memoirs of the Meteorological Office. Mention may be made of two unexpected results. The rate of increase of temperature upwards at the end of clear calm nights falls off much more rapidly with increasing height than had been expected on the plausible assumption that radiation was the main operating factor; and, most surprisingly, the mean temperature over the twenty-four hours of the day, generally supposed to decrease upwards, was found to *increase* upwards on the average of the whole year, to a height of 100 ft. Recent records from the tower at Rye, erected at Johnson's instigation, to investigate the vertical distribution of humidity, the fundamental factor in the strange, but vitally important, anomalous radar phenomena, show that there the increase of temperature persists up to 300 ft.

After 1928 Johnson became successively director of experiments at the Chemical Defence Research Establishment at Porton and chief superintendent of the Chemical Defence Research Department of the War Office. During this period the defence arrangements against gas attacks, including the gas masks, admittedly superior to any others in the world at that time, were brought to such a pitch of perfection that they were a major factor in deterring the Nazis from attempting gas attacks against Britain or against her ally, the U.S.S.R., whose civil population had no such effective protection.

In September 1938 Johnson returned to the Meteorological Office as director. His happy combination of scientific comprehension and administrative ability won the admiration of his staff. He devoted all his energy and his time to the task of meeting the demands which the threat of imminent war and, a year later, the outbreak of war, made upon the Office. His foresight enabled him to meet the unprecedented requirements for staff and equipment for Army and Air Force needs not only in the United Kingdom and in the expeditionary forces in Europe and North Africa, but also in the Middle and Far East, in the Colonies, Malta, Iceland, the Azores and partially in Canada and South Africa.

But Johnson was not only an able administrator; he never lost sight of the need for fundamental research. He instituted the Meteorological Research Committee with Prof. S. Chapman as its first chairman; he secured the establishment of the Meteorological Research Flight, the contributions of which to our knowledge of the upper atmosphere, especially of humidity in the stratosphere, have been outstanding; and he formed a section for research in forecasting, working in contact with, but freed from the routine duties of, the operational forecast service.

Meteorology is more dependent than any other science on international co-operation. Johnson took the lead after the Second World War in convening an international meeting in London at the beginning of 1946. He was elected chairman of the International Meteorological Committee and in 1947 president of a general 'Conference of Directors' at Washington, where he achieved an outstanding success. He secured agreement among these directors and their diplomatic advisers, including those of the U.S.S.R. and countries in the Soviet block, on a Convention of Governments establishing an official World Meteorological Organization with the necessary

financial provision and an agreed degree of flexibility in its operation. When the Conference was on the point of breaking down, it was, to quote the words of the Chief of the U.S. Weather Bureau, "the deliberate and skilful guidance of the President" which brought them through all obstacles.

Johnson was made K.C.B. in 1943. We who served under him appreciated and admired his ability, and I am assured that those who served with him and under him in chemical defence research share our feelings and mourn our loss. The strain of the past fifteen years caused or accelerated the development of Parkinson's disease, which defeated our hopes that he would regain his health after his retirement at the end of August last; he died on March 23.

Throughout nine years I saw almost daily evidence of his quiet power and his thoughtful tact. I may mention one illustration. A member of the staff had got into difficulties through his own blunder and deserved censure. When the matter came to Johnson, his first words to me were, "How can we help *X* out of his difficulties?" He was not only kind; he was strong. When he had decided what was the right course, he could state clearly the decisive reasons for it and reveal reserves of power behind an unassuming manner. The Chief of the U.S. Weather Bureau said the Washington Conference owed him a debt of gratitude; so does his own country.

E. GOLD

Prof. K. Honda

THE death occurred on February 12 of Prof. Kotaro Honda in his eighty-fourth year, an almost legendary figure in the field of physical metallurgy and applied physics. Born on February 23, 1870, the second son of Hyozabuso Honda, in the Aichi Prefecture of Honshu, Japan, he graduated in 1897 as a physicist from Tokyo Imperial University. Making his mark while still a research student, he published several papers in collaboration with Prof. H. Nagaoka and alone, on the dimensional effects of magnetization on iron and steel, nickel and cobalt. In 1901 his University appointed him a lecturer in physics and in 1903 conferred the D.Sc. degree on him. During this period his researches were devoted mainly to magnetic subjects such as the dimensional effects observed at high and low temperatures, the effect of stress on magnetization, and the change in the elastic constants of ferromagnetics with magnetization. His wide interests at this time are demonstrated by several papers on geophysical matters. Honda repeated and extended a great deal of the magnetic work done by earlier investigators but exercised greater care and added many refinements, often in very simply conceived apparatus.

Between 1907 and 1911, Honda travelled as a research fellow in Germany, France and England. While in Europe, he worked under Prof. G. Tammann, of the University of Göttingen, in the field of metallurgy and under Prof. du Bois on magnetism. In 1910, he published a famous paper covering the first extensive and systematic investigation made into the magnetic susceptibilities of the elements, about forty in all, but most of the data are now considered unreliable because of impurities. Following his period abroad, Honda was appointed professor of physics at the then newly established Tôhoku Imperial University at Sendai.

A long and prolific period of valuable experimental and theoretical work then followed, on the magnetic properties of elements and alloys at high and low temperatures; contemporary theories of magnetism; the structure of magnet steels; the solution of equilibrium diagrams by magnetic analysis; the invention of *K.S.* permanent magnet steel in 1920 (now better known as 35 per cent cobalt magnet steel); the nature of the transformations in pure iron and carbon steels; the theory of the quench-hardening of steels; the study of the formation of cementite; the production of single crystals of iron, cobalt and nickel and their magnetic investigation; the study of martensite; and the development of the new *K.S.* permanent magnet alloy in 1934. Indeed, his stimulating contributions covered so many branches of the physics of solids and physical metallurgy that it would be invidious to single out any one group for special comment.

Honda's contribution to the establishment of fundamental and applied scientific research in Japan cannot be over-rated; and his influence on, and encouragement of, his students and research associates gave rise to the large output of valuable papers which appeared in the *Tôhoku Science Reports*. He was appointed director of the Research Institute for Iron, Steel and other Metals in 1919, after fostering its foundation. He was also elected a member of the Imperial Academy of Science; the National Research Council of Japan; the board of directors of the Foundation for the Promotion of Science and Industry in Japan; and the Tokyo Institute of Physical and Chemical Research. Finally, he became president of the Tôhoku Imperial University in 1931, which appointment he held until his recent retirement.

A notable stage in Honda's career was reached in 1936, when he attained his twenty-fifth anniversary as professor of physics in the Tôhoku Imperial University. This was marked by the publication of the "Honda Anniversary Volume", a unique compilation including papers from past pupils and colleagues and contributions from leading physicists of international repute.

The Iron and Steel Institute conferred its highest honour, the Bessemer Medal, on him in 1922; this was only one of many awards and honours received by Prof. Kotaro Honda from Great Britain, the United States and Germany, which confirm the great international esteem in which both the man and his work were held.

Prof. Eugeniusz Romer

THE death of Prof. E. Romer on January 28 at the ripe age of eighty-four marks the end of an era of cartographical and geographical development in Poland for which he was so largely responsible. His forceful and dynamic personality never failed to make its mark whenever he attended a meeting or conference and will be recalled with pleasure by the many friends he made in Britain at the International Geographical Congress of 1928. The high standard of official maps of Poland and the wide range covered are due especially to his efficient direction. He remained mentally vigorous almost to the day of his death, and in his retirement had turned his attention to some theoretical aspects of geomorphology, notably the development of the river systems of Africa. It is hoped that a summary of this work in English, already planned at the time of his death, may appear posthumously.

L. DUDLEY STAMP

NEWS and VIEWS

Physics at Bangor: Prof. E. A. Owen

Prof. E. A. Owen retires in September this year from the chair of physics in the University College of North Wales, Bangor, which he has held for the past twenty-eight years. A graduate and 1851 Exhibition Scholar of the University of Wales, Prof. Owen went to the Cavendish Laboratory, Cambridge, in 1910 for postgraduate work under J. J. Thomson, where his work on X-ray absorption led to the discovery of the λ^3 law which is associated with his name. He afterwards joined the staff of the National Physical Laboratory, Teddington, at first holding a post in the Metrology Division, and later became head of the Radiology Section of the Physics Division. There he was largely concerned with the protection of hospital staff in X-ray and radium departments and with X-ray dosage measurements. He served for many years as secretary both to the British and to the International Committee for Radiological Units and took a prominent part in establishing the roentgen as the unit of X-ray dosage and in having it adopted as the international unit. At the National Physical Laboratory, in addition to organizing the routine work, Prof. Owen was active in promoting original research. Under his guidance, with the active co-operation of the late Walter Rosenhain, then superintendent of the Metallurgy Division, and G. D. Preston, now professor of physics in University College, Dundee, work on the crystal structure of metals and alloys was started in 1922 and has continued at the Laboratory ever since. He was also interested at this time in the reflexion of electrons from crystal surfaces, and it is worth while recording that he was only narrowly forestalled in the discovery of electron diffraction. During the tenure of his chair at Bangor, Prof. Owen has built up a reputation for the application of X-ray methods to the elucidation of the structure and properties of metals and alloys. The work of his Department has been characterized by attention to detail and accuracy of X-ray measurements which have done much to throw light on many phase diagrams of binary alloys and related problems.

Dr. E. R. Andrew

Dr. E. R. Andrew, who succeeds Prof. E. A. Owen, has had a distinguished scientific career at Cambridge and Harvard, and latterly at the University of St. Andrews. An open scholar of Christ's College, Cambridge, he took first-class honours in Part 2 of the Natural Sciences Tripos in 1942, and then went to the Radar Research and Development Establishment, where he worked mainly on problems of radar reception and display. He returned to the Royal Society Mond Laboratory in Cambridge after the War to do research on superconductivity and was elected Stokes Student at Pembroke College in 1947. His research was principally concerned with the problem of the intermediate state, that is, the break-up of a superconductor into alternate regions of normal and superconductive material when a rod or plate of the superconductor is subjected to a transverse magnetic field of sufficient strength. His experimental and theoretical work cleared up much that was uncertain in the phenomenon and showed unmistakably the very important part played there by the surface energy of the boundary surface between normal and superconductive regions. Dr. Andrew left the Mond Laboratory to spend a year as Commonwealth Fellow at Harvard University and was then appointed to a lectureship in natural philosophy in the United College of the University of St. Andrews in 1949. At Harvard he began his work with Prof. Purcell on proton magnetic resonance in solid hydrocarbons and has continued this at St. Andrews, where he has designed and had built a very large permanent magnet which has a highly uniform field, such as is needed for this kind of research. The work which he and his research students have carried out on nuclear magnetic resonance in molecular hydrocarbon crystals has yielded much valuable information. It has been possible to determine unambiguously the positions of the protons in many molecules, to determine the modes of rotation of the hydrocarbon molecules in the lattice, to measure the frequencies of rotation and the height of the potential barriers which hinder rotation and, further, to show, in such crystals as benzene, that the molecules are very free to migrate between lattice sites even at temperatures well below the melting point of the solid.

Agriculture at Nottingham: Prof. F. L. Milthorpe

Dr. Frederick Leon Milthorpe, head of the Department of Plant Physiology at the Waite Agricultural Research Institute, University of Adelaide, has been elected to the newly established chair of agricultural botany in the Department of Agricultural Sciences at the School of Agriculture in the University of Nottingham, as from next October. Dr. Milthorpe is an agricultural science graduate of the University of Sydney, and in 1940 became a plant pathologist in the New South Wales Department of Agriculture, a position he held until 1946. During this period his research work concerned the search for rubber substitutes, the growth of fibre flax and of vegetable crops, and diseases of deciduous fruits. During 1946–49 he held a Farrer Scholarship and a Leverhulme Research Fellowship at the Imperial College of Science and Technology, London, investigating the drought resistance of cereals. He has continued research in problems of water relations of plants while holding his present appointment, since 1950, as senior lecturer in charge of plant physiology at the Waite Institute in South Australia.

Geography at University College, Swansea: Prof. W. G. V. Balchin

Dr. W. G. V. Balchin, who has been appointed to the newly established chair of geography at University College, Swansea, received his early training in the Cambridge School of Geography. After serving as demonstrator at Cambridge, he worked in the Hydrographic Department of the Admiralty during the War and was appointed lecturer in geography at King's College, London, in 1945. He has worked in the fields of geomorphology and climatology, making notable additions to our knowledge of coastal processes, of the erosion surfaces of south-west England and to the study of local climates. In 1952 he organized an expedition to Arizona in association with Mr. Norman Pye, of the University of Manchester, and the first fruits of the work then done are in course of publication. He had earlier visited Spitsbergen with the 1938 University of Cambridge expedition. His contributions to his subject have been recognized this year by the receipt from the Royal Geographical Society of the Gill Memorial Award. As head of the Department at Swansea he is well equipped to establish a school, giving full

attention to the physical and cartographic aspects of the subject and thus providing a valuable complement to the well-known and long-established school of human geography at Aberystwyth.

Geography at Southampton : Miss F. C. Miller

Miss F. C. Miller, head of the Department of Geography in the University of Southampton, is retiring at the end of the present academic year. Miss Miller has been a lecturer at Southampton since 1921 and head of the Department for many years. She has maintained the status of the Southampton Department, one of the earliest in the country. The Department has contributed to the subject many academic workers now holding responsible positions in several universities in Britain.

Mr. F. J. Monkhouse

Mr. F. J. Monkhouse, of the University of Liverpool, has been appointed to succeed Miss Miller, with the title of professor. Mr. Monkhouse graduated in 1935 with a first in the Cambridge Geographical Tripos and, after experience as geography master in several grammar schools, joined the Naval Intelligence Division of the Admiralty in 1941. He was one of the team of workers which produced the "Geographical Handbooks" for Service use ; his own contributions were chiefly on West European countries. After a short spell in Ceylon with the Inter-Service Topographical Division, he was appointed to the Department of Geography in the University of Liverpool in 1946. While in Liverpool, he has been most active in both teaching and research. In particular, he has developed cartographical teaching to a high level and, in collaboration with Mr. H. R. Wilkinson, also of the Liverpool Department, has written "Maps and Diagrams", which has become a standard text. His book "The Belgian Kempenland" (in the series "Liverpool Studies in Geography") and his papers on the economic geography of the Low Countries indicate his interests in the economic geography of Western Europe, and he has in addition a number of papers on the historical geography of England, including a chapter on Worcestershire in the forthcoming second volume of Prof. Darby's "The Domesday Geography of England".

Element 100

The announcement in *The Times* of April 12 of the production of element number 100 by Prof. G. T. Seaborg and his collaborators at the University of California follows closely on their discovery of element 99 (see *Nature*, February 13, p. 290, and *Phys. Rev.*, **93**, 257 and 908 ; 1954). Although full details of this work have not yet been published, it is clear that extreme care in the handling of minute quantities of short-lived radioactive products was necessary, and the successful outcome of the experiments is a major technical achievement. The mass number of the isotope of element 100 that has been identified is given as 253, and its half-life is about three hours. It was prepared from a plutonium isotope (presumably plutonium-239) by successive neutron capture, which increases the mass, followed by beta-decay, which increases the atomic number. As a first stage in the process, californium (element 98) was separated chemically from the irradiated plutonium, probably by ion exchange and precipitation methods ; the californium in turn was bombarded by neutrons, and elements 99 and 100 so obtained. Since it appears that at least fourteen neutrons must have been added to the original material to arrive at the mass number quoted, it is obvious that the work demanded very intense neutron fluxes, such as are available in the reactors of the U.S. Atomic Energy Commission. Identification of the new isotope was presumably based on the α-decay systematics, built up by Prof. Seaborg and others, which have proved extremely reliable in this field. Element 100 is stated to behave chemically like erbium, its analogue in the rare-earth group. There is no reason for believing that this will be the last new element to be prepared, although the increasing probability of spontaneous fission as the atomic number advances would appear to limit the total number of elements to about 110.

Colonial Relations in the British Commonwealth

Replying for the Government in a debate in the House of Commons on April 2, initiated by Mr. C. J. M. Alport on a resolution calling for re-examination of the spheres of responsibility of the Colonial and Commonwealth Relations Offices and reorganization of the services for which they are responsible, the Minister of State for Colonial Affairs, Mr. H. Hopkinson, rejected the suggestions made in the debate for appointing a Secretary of State for Africa, merging the Colonial Office and Commonwealth Relations Office, or transferring the economic functions of the Colonial Office to the latter Office. In the Government's view the time has not yet come for any major definition of the spheres of responsibility between the Commonwealth Relations Office and the Colonial Office. Nevertheless, it might be desirable to examine the relations between the respective services and the need for the reorganization of the Colonial Office as a whole. In the view of the Government, re-examination of the conditions of service of members of the Colonial Service is urgently needed, for it is of the greatest importance that Colonial officers should be assured that their problems and anxieties are understood and treated seriously.

Mr. Hopkinson did not think that the proposal for a joint Commonwealth service would help this particular problem, but he would not exclude schemes in which Colonial servants, as part of some new overseas service, could be made available when required by independent Commonwealth countries or indeed by foreign countries. The Government recognizes that it has a special responsibility towards officers of the Colonial Service who, appointed to their present posts by the Secretary of State, are in those areas developing towards full self-government which are anxious to ensure that officials retained by them should owe principal allegiance and loyalty to them. Up to now, Colonial Governments have not behaved irresponsibly or unfairly towards their British Civil servants, but the Government feels that, as long as these officers remain, they should be assured of certain basic conditions of service, including pensions and other benefits, retention of their status in H.M. Colonial Service, and possibilities of transfer and promotion, and so on. At the same time, they should be permitted to retire from the service of the Colonial country by which they are employed when it attains independence. The Government, said Mr. Hopkinson, believes that there is still a great work for these officers and wishes them to know that the House and Government are aware of their needs and are determined to give them every practical assistance for carrying on their great task.

Age of Election to the Royal Society

In a recent note, Prof. A. V. Hill has discussed the age of election to the Royal Society of London (*Not. and Rec. Roy. Soc., Lond.*, 11, No. 1; January 1954). For many years, up to and including 1930, the number of annual elections to fellowship of the Royal Society (apart from 'special' elections under Statute 12) was fifteen. During 1931–38 it was seventeen, during 1939–45 it was twenty, and since 1946 it has been twenty-five. The 'median' age of election (that is, the age above which as many elections occur as below it) has been shown as: 1848–72, 42; 1873–97, 43; 1897–1922, 44½; 1920–38, 47; 1939–45, 48½; 1946–53, 47½. These figures include elections in all scientific categories. In eight different categories the median ages have been:

	1920–38	1939–53
Mathematics	42	42
Physics	39	44
Chemistry	45	45
Engineering	55	54
Geology	53	51
Botany	51	52
Zoology	48	50
Physiology	48	49

This confirms the general conclusion that there has been little change over the past thirty-four years, though this is probably due mainly to the fact that the number of annual elections has increased in the ratio of 5 : 3. The median age of election differs greatly between the categories; and this difference is the more striking when it is recalled that practically no elections take place under thirty-two, so that, for example, half the elections occur in ten years in mathematics and in twenty-two years in engineering. One reason for this difference is that in some subjects experience is far more important than in others, where natural ability is the chief element in success. Prof. Hill writes that the number of scientific people qualified for election is rising rapidly and that, if seventeen elections annually were appropriate in 1931, twenty-five will be too few before long. The number of annual elections should be adjusted from time to time so that the median age of election could be kept around forty-five.

Impact of Science on Society

Recent copies of the quarterly magazine, *Impact*, have contained articles of considerable interest to those interested in the social aspects of science. In the latest issue, Dr. A. King states that international collaboration in scientific research and development can be extremely valuable only if the projects are appropriate for international effort and present real advantages over normal national or institutional means. International scientific co-operation should be based on real needs rather than on idealistic or political principles (4, No. 4; Winter 1953). An earlier issue of the journal contains an article by Dr. C. Sarnie on the scientific detection of crime; he shows that the introduction of scientific methods in the detection of crime is of great social value because it makes for greater certainty in the administration of justice (4, No. 3; Autumn 1953). In the Summer 1953 issue (4, No. 2), R. T. Eddison has contributed a valuable article on the social application of operational research, and Dr. Armando Cortesaa, the distinguished Portuguese historian of science, has shown how the application of nautical science made possible the great geographical revolution at the end of the fifteenth century. *Impact* is available at H.M.S.O., price 2*s.* 6*d.* for each issue.

Imperial College of Science and Technology, London

An account of research activities carried out at the Royal College of Science during the three years, 1950, 1951 and 1952, has recently been published. The publication is a brief general review and is written in non-specialized terms similar to the booklet issued by the City and Guilds College last year to describe its research in engineering. Contributions are included from eight departments of the College, including botany, inorganic and physical chemistry, organic chemistry, geology, mathematics, meteorology, physics and zoology and applied entomology. The greatest range of investigation has been carried out in the Department of Inorganic and Physical Chemistry and varies from analyses of the structure of solids to the physical chemistry of ion-exchange resins as well as problems of crop nutrition and insecticide chemistry. In the Department of Geology, studies have been carried out on the Caledonian Mountains of Britain, while, in the Department of Mathematics, theoretical cosmology has been one of the fields of investigation. The report is admirably written and discreetly illustrated. It is hoped that, next year, the Royal School of Mines will publish a similar booklet, so completing a trilogy of publications of this sort for the three colleges which make up the Imperial College of Science and Technology.

Rugby School Natural History Society

The Report of the Rugby School Natural History Society for 1953 is the eighty-seventh in the series and reveals that the Society is in a flourishing state and is keeping up a long and splendid record of work. The museum has been redecorated and extended, and the vivarium improved mainly by clearing, cleaning and restocking the pond. During the year, four lectures were given by visiting specialists. The ecology of a pond has been the subject of study for about thirteen years. An account of the period 1940–46 was published in the Report for 1946, and in the present Report the account, with illustrations, has been brought up to date. A bird census for 1953 is given. T. Fawcett describes work on an excavation at Brownsover, where pieces of interesting medieval pottery were unearthed; so also were two St. Neots ware sherds dating from late Saxon time and believed to be the first found in Warwickshire. Reports of the library, museum and vivarium and of the Society's field sections—zoological and entomological, ornithological, geological, archæological—are here published. (It is curious that the Society seems to have no botanical field section, though judging from the report of the zoological and entomological section, its members also admit botany.) Affiliated sections also report their year's activity; they comprise architectural, meteorological, photographic, astronomical, chemical and physical, railway, wireless and aero-modelling. Numerous prizes covering many aspects of science are being offered. Rugby School is to be congratulated on the excellent work being done by its Natural History Society and affiliated sections.

Science Service of the Canadian Department of Agriculture: Annual Report for 1952–53

The annual report of the Director of Science Service of the Department of Agriculture, Canada, for the year ended March 31, 1953 (pp. 56+4 plates. Ottawa: Queen's Printer, 1953), which is reprinted from the report of the Minister of Agriculture,

endeavours to give a representative picture of the work going on in the Ministry's various laboratories across Canada, more particularly the work directly related to important problems in agriculture and forestry. The extent and variety of this work is shown in a list of 284 research papers published during the year, which is appended to the report. In animal science, investigations were concerned with the basic aspects of nutritional and physiological problems and the protection of livestock and man from animal pests. Experiments in Alberta with spraying and dusting machines, for example, showed that spraying sheep with DDT in the spring was effective against tick, being more rapid than dusting and easier on the animals. Loss of repellency of dimethyl phthalate to mosquitoes was found to be due largely to absorption through the skin, while a rotary-brush spraying device attached to aircraft, which has been developed by the Entomology Division, proved the most effective and economical spraying device so far tested. In plant science, emphasis is placed on researches relating to hazards confronting farmers and foresters from plant diseases and insect pests, and the bulk of the report records the many useful results obtained in such investigations. A further section of the report describes the work in soil science, including microbiology, soil chemistry, taxonomy and antibiotics, while professional services, both organized and informal, which were rendered to different groups within the Department of Agriculture, to other Dominion Departments and to the public, constitute an important feature of the activities of the Department.

Carotid Rete and its Associated Arteries

A PAPER entitled "Studies of the Carotid Rete and its Associated Arteries", by P. M. Daniel, J. D. K. Dawes and Marjorie M. L. Prichard (*Phil. Trans. Roy. Soc.*, B, **237**, pp. 173–208 + pls. 12–19; July 1953; 8*s*.), records an investigation into the cranial arteries in a series of mammals more particularly with respect to the well-known rete mirabile cerebrale, here termed the carotid rete. The animals employed were cat, sheep, ox, goat, pig, dog, rabbit and rat. The rete was found to be well developed in the first five, in a very much reduced form in the dog, but not at all in rabbit or rat. The techniques employed were the use of radio-opaque injection masses from which stereoscopic radiographs were taken, and of injection with neoprene latex. After the setting of the latter, the vessels were dissected *in situ* or the tissues were completely macerated, leaving only the casts of the blood-vessels. This enabled the position of the main vessels in relation to one another and to the bony tissue, the relation of the vessels to the soft tissue and finally the detailed structure of the rete and its associated vessels, to be readily ascertained. How successful the neoprene latex injections were is clearly shown in the nineteen excellent photographs on the eight plates. The rete is found to be intimately associated with the major arteries supplying the brain, and its presence is associated with a reduction or absence of the internal carotid artery. This is still true of the cat where, in contradistinction to the artiodactyles, the rete is extracranial, lying in a venous lake surrounding the internal maxillary artery immediately below the base of the skull. In the other forms the rete lies intracranially in the cavernous sinus. The rete itself consists of a network of medium-sized arteries about 250 μ in diameter, which interlace and anastomose in a complicated manner. It would appear from its size, its complexity, its relation to the cranial blood supply and its close association with venous blood, that it must serve some functional need; but what this need is or how it is served remain unsolved problems.

The Oriental Earthworm

THE value of earthworms in increasing fertility of the soil is well known. There are situations, however, in which the good done by earthworms is outweighed by the damage and inconvenience that they cause. In recent years a new species, the Oriental earthworm, *Pheretima hupeiensis*, has appeared in Connecticut and other eastern states of U.S.A. It has proved to be a much more serious pest than the native species and is more or less immune to treatments used to kill native earthworms. J. C. Schread has described the habits of the new earthworm and experiments on its control in specialized turf areas (Bull. 556; April 1952; Connecticut Agricultural Experiment Station, New Haven). The worm is apparently very prolific and the production of hundreds of casts following heavy rainfall has seriously damaged golf greens; hundreds of pounds of castings have been left on each heavily infested green every year. Control measures used for native earthworms were not effective in controlling the Oriental earthworm. Parathion applied four times, totalling about a hundred pounds per acre, reduced the population about 97 per cent; some injury was caused by the final application. Chlordane emulsions were more effective than wettable powders. Single treatments using 40 pounds of chlordane per acre had a highly killing effect and prevented reinfestation for long periods of time. Aldrin in the form of either wettable powders or emulsion at the rate of 33 pounds per acre first activated the worms, but provided good control after several weeks. Other chemical reagents also produced good results.

Enzymes of *Aspergillus oryzae*

THE sequence of appearance of the enzymes liberated by *A. oryzae* during its growth and some of the properties of these enzymes have been described and discussed in a series of studies by W. G. Crewther and F. G. Lennox (*Austral. J. Biol. Sci.*, **6**, 410, 428, 447; 1953). When a strain of the mould *Aspergillus oryzae* is grown in surface culture on a protein-free sucrose-tartrate medium, enzymes are released into the culture medium in the following order: first, the carbohydrases sucrase and amylase together with phosphatase; second, the proteases and esterases; and third, catalase. Their liberation is accompanied by the appearance of protein nitrogen in the medium and loss in weight of the mycelium. Evidence is presented for the presence of at least two proteases in addition to glycylglycine dipeptidase —one reduces the viscosity of gelatin very rapidly and is believed to act preferentially on the high-molecular-weight fractions of gelatin (the 'viscometric protease'), whereas the other degrades the lower molecular components of the gelatin more readily (the 'gravimetric protease'). The *p*H activity curves for sucrase and amylase also indicate the presence of more than one component. Inactivation of the various enzymes present during incubation at 40° C. and at different *p*H values has been followed. These papers also give a full account of the fractionation and preparation of crystals rich in protease and of the ethanol fractionation of enzymes at low ionic strengths.

Macromolecular Chemistry: Symposium in Italy

A symposium on macromolecular chemistry will be held in Milan and Turin during September 27–October 3 under the auspices of the Commission of Macromolecular Chemistry of the International Union of Pure and Applied Chemistry. Four subjects will be discussed at the symposium: characterization of polymers in relation to their technical properties (molecular weight and molecular-weight distribution, branching and cross-linking, and crystallization); building reactions of macromolecules; transformation reactions of macromolecules; and block polymers and graft polymers (preparation and properties). Papers will be considered for the symposium, written in French, English, Italian and German, and must be submitted before April 30; those covering the first subject should be sent to Prof. Antonio Nasini, Istituto Chimico, Università, Corso Massimo d'Azeglio 48, Torino, and those for the other three subjects to Prof. Giulio Natta, Istituto Chimica Ind. Politecnico, Piazzale Leonardo da Vinci 32, Milano, who together will be the editors of the publication of preprints and proceedings. The papers and discussions will be published in a special issue of *Ricerca Scientifica* which will appear shortly after the end of the meeting. People in Britain wishing to attend should write in the first place to the British National Committee for Chemistry, Royal Society, Burlington House, London, W.1.

Council for the Promotion of Field Studies

The Council for the Promotion of Field Studies organizes a very large number of courses throughout the year which should appeal to many persons, both amateur and professional, with outdoor interests or hobbies. The courses are generally based on one of the Council's four field centres: Flatford Mill, East Bergholt, near Colchester, Essex; Juniper Hall, Dorking, Surrey; Malham Tarn, near Settle, Yorkshire; and Dale Fort, Haverfordwest, Pembrokeshire, with which is also associated the Skokholm Bird Observatory. The Council is particularly well known to naturalists of all descriptions, with specialized interests in the whole field of the plant and animal kingdoms; but the term 'field studies' goes well beyond the biological world, and those interested in, say, oceanography, geology, archæology, geography, mapping and surveying, and meteorology will find their tastes catered for. Again, the standards are varied and range from the quite elementary to the advanced; courses tending towards the latter category are often run in conjunction with some other organization, prominent among which is the University of London. The field centres take about fifty persons at a time (many of whom can be accommodated in single rooms or cubicles), and there are well-equipped laboratories and basic outdoor equipment at each to keep the students fully occupied. The normal period of residence is one week, and the charge, which includes full use of the centre as well as board and lodging, is £5 15*s*. 6*d*. a week (Skokholm £4 14*s*. 6*d*.). Further information about each field centre and its courses can be obtained from the wardens at the above addresses, or from the Publicity Officer of the Council at Ravensmead, Keston, Kent.

Colonial Service: Recent Appointments

The following appointments have recently been made in the Colonial Service: T. Y. Watson (director of agriculture, Uganda), secretary for agriculture and natural resources, Uganda; J. A. Burra (assistant conservator of forests, Windward Islands), assistant conservator of forests, Cyprus; A. M. J. De Swardt (senior geologist, Geological Survey Department, Nigeria), principal geologist, Geological Survey Department, Nigeria; P. B. N. Jackson (scientific officer, Northern Rhodesia), senior scientific officer, Northern Rhodesia; K. H. Bain (fisheries officer, Gold Coast), fisheries officer, Federation of Malaya; C. P. Wood (senior agricultural survey officer, Gold Coast), principal agricultural survey officer, Gold Coast; G. Stell, entomologist, Trinidad; A. R. Rees, awarded a Colonial research studentship with the view of appointment as a scientific officer (plant physiologist); F. J. Parker, veterinary officer, Uganda; R. J. Campbell, veterinary officer, Gold Coast; D. Clay, veterinary officer, Department of Agriculture, Jamaica; P. J. French, veterinary officer, Kenya; A. R. Mahood, entomologist, Veterinary Department, Nigeria; E. C. Trump, field zoologist, Veterinary Department, Kenya; J. L. Williams, statistician, East Africa High Commission.

Announcements

Prof. A. Kastler, of the Faculty of Sciences, University of Paris, has been awarded the Holweck Medal and Prize for 1954 and will deliver the ninth Holweck Lecture in the rooms of the Royal Astronomical Society, Burlington House, London, W.1, on May 13, his subject being "Les Méthodes Optiques d'Orientation Atomique et leurs Applications". The Holweck Medal was founded by the Physical Society as a memorial to Fernand Holweck and to other French physicists who suffered or met their deaths during the occupation of France during 1940–44 and is presented in alternate years to a French physicist and to a British physicist, the recipient being a physicist distinguished for his work in experimental physics.

Dr. J. R. Nicholls is retiring from the post of deputy government chemist on April 30 after forty-three years in the Department of the Government Chemist. His services are being retained in another capacity. His successor will be Mr. E. H. Nurse.

A Western Section of the Society for Analytical Chemistry has recently been formed following an application signed by many members resident in the West of England, and the inaugural meeting will be held at noon on May 8 in the Lecture Theatre of the Technical College, Newport, Monmouthshire. After a business session in the afternoon, Dr. D. W. Kent-Jones, president of the Society, will address the Section on "Alcohol Determination and its Medico-legal Aspects".

Three special summer courses will be held in the Massachusetts Institute of Technology as follows: June 15–25, developments in machine-tool technology (under Prof. M. C. Shaw, of the Machine Tool and Metal Cutting Division, Department of Mechanical Engineering); June 16–29, operations research as applied to solving industrial, business and government problems (under Prof. P. M. Morse, professor of physics); and August 23–September 3, automatic control of machine tools (under Prof. J. F. Reintjes, director of the Servomechanisms Laboratory). Application forms and further information on these courses can be obtained from the Summer Session Office, Room 7–103, M.I.T., Cambridge 39, Mass.

RADIO-METEOROLOGY

CONFERENCE IN TEXAS

A CONFERENCE on radio-meteorology was held in Austin at the University of Texas during November 9–12 last, sponsored by the American Meteorological Society, the Institute of Radio Engineers, the Radar Weather Conference, and the American national groups of Commission II of the International Scientific Radio Union and of the Joint Commission on Radio-Meteorology of the International Council of Scientific Unions. Some two hundred participants, widely representative of university, government and industrial scientific laboratories, attended the meetings.

The subject of radio-meteorology, which embraces several aspects both of the influence of meteorological factors on radio-wave propagation and of the use of radio techniques for studying features of the weather, has expanded greatly and increased in importance during the past few years. Work is still in progress in different parts of the world which is directed to the explanation of phenomena of which something was known twenty or more years ago; in addition, new fields of investigation, largely stimulated by war-time experiences in the operation of centimetre-wave radar, are being intensively pursued.

Tropospheric Wave Propagation

The conference was organized into eleven sessions, and the first four of these were concerned with the effects of the troposphere on the propagation of very short radio waves. The first paper, by T. J. Carroll, presented a review of existing knowledge of tropospheric propagation to points well beyond the horizon. Experiments during recent years have shown that, at such ranges of transmission, radio field strengths at very high frequencies are much greater and more reliable than have been predicted from standard theory. Of the explanations advanced to account for this phenomenon, there was considerable discussion of two, namely: that the fields are due to scattering of incident radiation caused by turbulent fluctuations of the refractive index of the atmosphere; and that the partial internal reflexion arising from the normal negative gradient of refractive index in the atmosphere is in itself sufficient to give fields of the order of magnitude of those observed. But it would appear that the explanation in terms of scattering by turbulent eddies finds the greatest support. Although it is felt that the scattering theory needs some refinement, it is not generally considered that the partial internal reflexion hypothesis has anything to offer towards such refinement; some account must ultimately be taken of the fact that the scattering centres are not spherical, which has so far been assumed to be the case.

Scattering of radio waves from a turbulent elevated layer formed the subject of a paper by W. E. Gordon, who said that airborne radio-refractometer observations in the United States indicate that such layers occur frequently. Within the layer the scale of turbulence is observed to be somewhat larger, and the intensity many times greater, than the values of these quantities observed above or below the layer. The scattered power from the layer received at certain distances may easily equal or exceed that from an atmosphere without such a layer.

Centimetre-wave refractometers are being exploited on an increasing scale in the study of the detailed refractive-index structure of the atmosphere, and these instruments have now been carried by aircraft to altitudes of 25,000 ft. Investigations of this nature were described by C. M. Crain and J. R. Gerhardt, by L. W. Cowan and by P. B. Taylor. The development of this form of refractometer as a new and sensitive instrument for the exploration of the refracting properties of the atmosphere of interest both to the meteorologist and the radio engineer, represents one of the most important steps of recent years in this field of study. Measurements of atmospheric refractive index have already been made over many coastal and interior regions of the United States for a wide range of climatic conditions. Airborne soundings have shown the existence of intense discontinuity layers which are not nearly well enough delineated by ordinary radio-sonde ascents. Examinations of turbulent structure show scales up to hundreds of metres with fluctuations of refractive index in the free air of the order of 10^{-6} (1 M-unit)—except in extremely turbulent layers where greater fluctuations are found—and decreasing as the altitude increases.

Considerable interest was shown at the conference in the properties of elevated layers in which the lapse-rate of refractive index with height is significantly greater than that appropriate to the standard atmosphere. Such layers, which usually occur at various heights below about 10,000 ft., play an important part in the determination of very-short-wave propagation characteristics. B. M. Fannin described the application of ray-tracing techniques to the evaluation of radio field-strengths in the presence of these layers, and P. B. Taylor discussed the effect of the layers on air-to-air propagation at very high frequencies in producing what has become known as the 'radio hole'. As two aircraft fly apart at a constant height above one of these abnormally refracting layers, it is frequently observed that there is a deep fade in the radio signal during communication between the aircraft. This "radio hole' begins at a range of 50–200 miles, depending upon the heights of the aircraft and the layer, and continues out for a further 50–100 miles; beyond this the signal reappears in strength and rises, with intermittent fades, to levels well above the free-space value. Often a useful signal continues far beyond the normal radio-horizon. Some theoretical aspects of reflexion at elevated layers in very-high-frequency transmission between ground stations were outlined by F. H. Northover.

During the sessions on tropospheric wave propagation, a group of papers was presented by members of the staff of the Central Radio Propagation Laboratory of the National Bureau of Standards. Reviewing the programme of propagation research at the Bureau in the frequency band 100–1,000 Mc./s., J. W. Herbstreit said that the programme has included studies of terrain and meteorological effects on transmission loss within and beyond the line of sight. An important series of measurements is that being carried out with transmitters located at the Cheyenne Mountain Field Station, Colorado Springs, and with receiving points situated at various dis-

tances over the plains of Colorado, Kansas and Arkansas. B. R. Bean described the prolonged space-wave fade-outs within the radio-horizon which have been found to occur in these experiments at a frequency of 1,046 Mc./s. The occurrence of these fade-outs coincides with widespread nocturnal super-refraction, as evidenced by enhanced signals beyond the line-of-sight and ground modification of the refractive index profile. A paper on the meteorological instrumentation at the Mountain Field Station was presented by M. C. Thompson and K. O. Hornberg.

Climatic maps of the monthly average refractivity gradient have been drawn up for the United States for the hours of 03.00 and 15.00 G.C.T. These maps follow a regular climatic pattern, and the refractivity gradients have been correlated with the monthly median transmission loss of all available very-high-frequency propagation paths. The usefulness of this approach for the prediction of very-high-frequency transmission loss was discussed in a paper by B. R. Bean and Frances M. Meaney. Theoretical work at the National Bureau of Standards has sought to explain the observed propagation characteristics in terms of a modification of smooth-earth diffraction theory to include the effects of irregular terrain, climatic conditions, knife-edge diffraction and scattering in the turbulent atmosphere. It might perhaps be pointed out that much of the work of the Bureau in this field is designed to be of assistance to the Federal Communications Commission in the task of frequency allocation for various very-high-frequency and ultra-high-frequency services.

Other papers on tropospheric wave propagation were concerned with the prediction of diurnal field-strength variations at a frequency of 100 Mc./s. from synoptic data (by F. R. Bellaire and W. A. Arvola), a procedure which, although not yet fully explored, appears likely to prove fruitful; while L. J. Anderson and E. E. Gossard described attempts to deduce refractive index profiles within a surface duct over the sea from meteorological measurements at two heights only, and also the associated trapping of centimetre waves. The forecasting of propagation conditions from a knowledge of the synoptic situation also formed the subject of a paper by A. D. Hood and L. H. Doherty, in this case the aim being to predict the performance of a radar operating over Lake Ontario at a wave-length of 3 cm.

An account was given by C. W. Tolbert and A. W. Straiton of experimental observations on the transmission of 8-mm. waves over optical paths of various lengths up to fifty miles in which highly directive aerials were used. The signal-level was generally found to be in agreement with the free-space value corrected for absorption due to water vapour and oxygen in the atmosphere, although there were, as expected, fluctuations produced by atmospheric inhomogeneities over the path. Steady signals with small loss due to water droplets were experienced in fog, but severe attenuation was caused by showers of rain.

Thunderstorm and Tornado Atmospherics

The fifth session of the conference was devoted to the consideration of thunderstorm and tornado atmospherics, and the general problem of thunderstorm location from the observable characteristics of atmospherics. H. L. Jones described a programme of research which has as an objective the identification and tracking of tornadoes from observations of the peculiar and abundant electrical discharges accompanying severe storms. It has been found that a line-squall, even though it appears as an extended echo on a radar screen, is composed of a number of separate storm centres each acting as a generator of atmospherics; further, as the intensity of an individual storm centre increases, the rate of arrival of atmospherics at a given receiving station increases. By observing the rate of arrival of atmospherics, and also the distribution of high- and low-frequency components, it is possible to classify storms according to their severity. The more severe storms and tornadoes are characterized by an arrival rate of 10 strokes/sec. or more, and a predominance of high-frequency components.

The recording and classification of thunderstorm atmospherics by counter techniques was discussed by M. M. Newman, J. R. Stahmann and J. R. Anderson, while E. R. Pierce and T. W. Wormell, in a communicated paper, described work at the University of Cambridge which shows that regular night-time atmospherics consist either of a series of peaked pulses fitting the concept of successive ionospheric reflexions or of a smooth quasi-sinusoidal oscillation that does not obey the simple reflexion picture. Regions producing quasi-sinusoidal waveforms do not generate peaked atmospherics and vice versa, and all quasi-sinusoidal wave-forms observed at Cambridge originate from the south-west at distances exceeding 1,600 km. It was pointed out that observations near the eastern coast or the centre of the United States would assist in establishing the cause of these curious geographical effects.

The characteristics of the lightning discharge channel are important factors in the determination of the nature of atmospherics. The channel resistivity, its surge impedance, and the propagation velocity of the discharge all involve non-linear variations which lead to interesting stepped currents. It was shown by M. M. Newman how equivalent electrical circuits could be derived and used for the calculation of the currents in discharges; the currents so obtained are in good agreement with experimental observations.

What are believed to be the first P.P.I. photographs (pictures recorded on a cathode ray tube) that include information on atmospherics were presented by D. M. Swingle. This technique permits the detailed location of electrical activity among the radar storm echoes.

Cloud and Precipitation Physics

Cloud and precipitation physics were discussed in Sessions 6–9 of the conference. In a review of this field of study, S. E. Reynolds directed attention to the fact that observations have shown that it is unnecessary to invoke the Bergeron ice-crystal mechanism to account for certain types of precipitation occurring over much of the earth's surface. The development of precipitation particles without the intermediate stage of ice is well confirmed in tropical regions as well as in the middle latitudes for both coastal and inland areas.

The general characteristics of radar echoes obtained from various forms of precipitation were surveyed by Pauline M. Austin. A spherical rain-drop scatters radiation which is polarized in the same direction as the incident wave. For a non-spherical particle, however, some of the scattered radiation is cross-polarized, the proportion being dependent upon the shape, orientation and composition (ice, water or

mixture) of the scatterer. Measurements made with different polarizations, or observation of the cross-polarized component, should therefore give valuable information concerning these quantities. Such measurements are especially desirable in the case of bright-band echoes, where the values of the average echo intensity are difficult to interpret. It was suggested that future research in this field may well follow two rather different lines. The first is technical in nature, and includes improvement in the extent and accuracy of the measurements, overcoming problems such as saturation of the receiver and extraneous fluctuations, and the development of the instrumentation for the quick and easy observation of such quantities as precipitation-rate and turbulence. The second type of research is related to the interpretation of the experimental data. There are, for example, many occasions where the presence of the bright band at a relatively low altitude prevents the estimation of rainfall from echo intensity except at very short ranges. This indicates the need for an empirical relation which involves not only the echo intensity and the rate of precipitation of rain, but also other pertinent quantities such as the height of the bright band, the range, and the beam-width of the antenna. A more complete analysis of the physical processes occurring within the bright band is also needed.

There is in progress in the United States and Canada a considerable amount of work on cloud and precipitation physics, and on the deduction from the nature of precipitation echoes of such factors as rainfall intensity, the growth and melting of snow-flakes, and wind shear and turbulence. Other contributions to these topics at the conference were made by D. S. Johnson, with particular reference to rain from warm clouds in Hawaii; by P. M. Austin and R. Wexler on the subject of radar echo intensity at different levels in steady snow; and by K. L. S. Gunn, who presented radar evidence of a generating level for snow. In the last-named work a study of vertical radar records and upper-air data for twenty-two days of snow at Montreal has revealed that well-defined snow-trail patterns occur (on a height-range radar display) on days when the air aloft is stable. In these situations snow develops in discrete generating elements, of considerable lifetime, which exist in a layer of middle cloud. The top of this cloud is less than 200 ft. above a frontal surface on these stable days. At times when the warm air is unstable, the trail patterns are not so well defined, and the top of the cloud is farther from the frontal surface.

Further papers in the cloud physics section were those on the lowering of the bright band during heavy rain (R. Wexler and J. Honig), optical transmission through rain (D. Atlas), the deformation of large raindrops (J. E. McDonald), and the reliability of radar measurements of rainfall (F. A. Huff and J. C. Neill). D. Atlas also described some quantitative measurements at a wave-length of 1·25 cm. on the echo intensities of fog and rain. The echoes from light rain agree well with those calculated from the existing theory; but the measured intensities with heavy rain are a few decibels lower than the theory would indicate. An account was given by R. K. Moore of measurements made aloft of the distribution of drop sizes in thunderstorms by means of a shadowgraph technique.

J. S. Marshall discussed the manner in which the size distributions of raindrops may vary during the process of precipitation. In calculations relating to this, it is assumed that the distributions as they originate in cumulo nimbus cloud, or at the melting-level, are like those observed at ground-level, but more consistent. Subsequent developments, when the drops are falling, by raindrop coalescence, cloud accretion and evaporation modify the distributions only to a small extent, so that any changes could scarcely be distinguished within the experimental accuracy of most observations. In the case of showers, wind shear can lead to a separation of the drops according to size: the resultant error in the measurement of rate of rainfall by radar, however, should diminish greatly when an average is taken either over a period of a few minutes or over an area of a few square miles.

Observations of rain echoes using a continuous-wave radar system operating at a wave-length of 8 mm. were described by D. G. Kiely, who also commented on some peculiar super-refraction effects noticed in transmissions at the same wave-length over a one-mile sea-path. In the rain-echo experiments a comparison was made between a radar system operating with a single aerial and one with dual aerials. The results show that the intensity of echoes is much less with a dual than with a single aerial system, but that there is a well-defined distance of separation between the aerials of a dual system beyond which greater spacing leads to little decrease in echo intensity. It also appears that fluctuations of the echo signal are not very dependent upon the rate of rainfall over a fairly wide range.

Operational Uses of Weather Radar

The last two sessions of the conference were devoted to papers on the operational uses of weather radar. The radar storm-detection programme of the United States Weather Bureau was outlined by V. D. Rockney, and from this it appears that although, as M. G. H. Ligda pointed out, little direct progress has been made during recent years on the utilization of radar storm observations for weather-forecasting purposes, more rapid developments in this field may be expected in the near future.

Considerable interest was aroused by papers dealing with the nature of radar echoes obtained when tornadoes are within range of observation, for any assistance in the issuing of warnings which leads to the reduction of damage caused by tornadoes is naturally of great importance in the United States. J. C. Freeman described observations of radar echoes from storms associated with tornado situations in Texas during the spring of 1953: these observations showed that three tornadoes were closely linked with very large and intense cloud-echoes, and in all these cases the large echoes were in a region of observable convergence of the surface winds.

A new theory concerning physical processes in the development of tornadoes was advanced by F. O. Rossmann. According to this theory there is no updraught in the funnel of a tornado, as is generally assumed, but on the contrary there is a strong down-draught, caused by moist labile conditions, which is stabilized by the revolving motion of the air mass in the funnel. It was further suggested that it might be possible to destroy a tornado by causing the explosion of a missile, guided by means of weather radar, at the appropriate point in the tornado, an idea which was supported by R. H. Mayer. The new theory produced much controversy and was clearly unacceptable to many members of the conference.

D. M. Swingle and L. Rosenberg, from a meso-meteorological analysis of radar weather observations in relation to the passage of cold fronts, showed that the use of a single radar in this way can lead to a worth-while improvement of short-term (two to six hours) weather forecasts for the local region.

If a criticism of the conference as a whole may be ventured, it is that too many papers (some sixty in all) were presented. It might have been more profitable if a more careful selection of papers to be read had been made, thus allowing more time for general discussion.

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SIXTH INTERNATIONAL CONGRESS OF MICROBIOLOGY, ROME

REPORTS OF SYMPOSIA

THE papers presented at four of the six symposia held at the Sixth International Congress of Microbiology, Rome, have been published as supplements to the *Rendiconti dell' Istituto Superiore di Sanità**. The volume dealing with the Actinomycetes contains thirteen papers dealing with the morphology, classification and general biology of the group and will be of interest mainly to specialists. It includes three papers from S. A. Waksman's team at Rutgers University dealing with the subject from the antibiotic point of view, and one by H. G. Thornton and F. A. Skinner discusses the antagonism between Actinomycetes and other organisms in soil. D. Erikson contributes a study of mycelial variation. Views on classification are expressed by P. Negroni, A. R. Prevot, H. L. Jensen, G. Penso and E. Baldacci and his co-workers.

The volume on bacterial cytology is notable not only for its written content but also for the many excellent electron micrographs illustrating the papers. Special mention must be made of a hitherto unpublished photograph of a section of *Bacillus cereus* made by G. B. Chapman and J. Hillier, which illustrates Stuart Mudd's introduction, and the pictures accompanying W. van Iterson's paper on flagella. K. A. Bissett discusses the nature and importance of the cell envelope. Nuclear structures are dealt with in papers by E. Kellenberger, E. D. Delamater and R. G. E. Murray. S. Mudd presents his views on bacterial mitochondria, which are challenged by A. Winkler in another paper.

The third symposium, on microbial metabolism, contains important papers on protein synthesis by E. F. Gale and by J. Monod and M. Cohn, and a most interesting report on the study of *E. coli* metabolism from a genetic point of view by B. D. Davis.

It is a little unexpected not to find any discussion of protein metabolism included among the papers on interaction of viruses and cells, and most disappointing to find no illustrations of R. W. G. Wyckoff's views on electron microscope evidence of virus proliferation. P. Lepine's paper is, however, very well illustrated with electron micrographs of ultra-thin sections of virus-infected cells, although perhaps not all virologists will agree with his interpretation of them. More controversial is G. Penso's postulated life-cycle of a mycobacteriophage. R. Dulbecco's account of his studies of animal viruses in tissue culture by his phage technique will be read with interest by all virologists, as will P. von Magnus's paper on incomplete forms of influenza virus. Plant viruses are discussed by F. C. Bawden, N. W. Pirie, and K. M. Smith and N. Xeros, while J. G. Carr contributes a short outline of the problem of virus reproduction in relation to cancer.

* VIto Congresso Internazionale di Microbiologia. Actinomycetales, Morfologia, Biologia e Sistematica; pp. 221; 20*s.*, or 1,600 lire. Citologia Batterica; pp. 181+46 plates; 25*s.*, or 2,000 lire. Metabolismo Microbico; pp. 143+1 plate; 12*s.* 6*d.*, or 1,000 lire. Rapporti tra Virus e Cellula Ospite; pp. 110+32 plates; 15*s.*, or 1,300 lire. (Roma: Fondazione Emanuele Paterno. Oxford: Blackwell Scientific Publications, Ltd., 1953.)

NATIONAL SCIENCE FOUNDATION

REPORT FOR THE YEAR 1952–53

IN the report of the United States National Science Foundation for the year ended June 30, 1953*, details are given of the support that the Foundation is continuing for three general long-range surveys of fields of science which are planned to require up to three years to complete. The survey of physiological science is being conducted by the American Physiological Society, and the final report is expected in the autumn of 1954. That of the development and status of psychology is being conducted by the American Psychological Association and comprises two major parts: an evaluation of the status of psychological knowledge, with special reference to general scientific methodology, development of theory, and dependence upon empirical laws; and an analysis of occupations in psychology, including the supply, demand and utilization of scientific manpower in the various branches of the science. The survey of applied mathematics is being conducted under the direction of the National Research Council Committee on Training and Research in Applied Mathematics in co-operation with the Defense Department.

Jointly with the universities, scientific societies and other government agencies in the United States, the Foundation sponsored eight conferences during the year, covering astrophysics, photosynthesis, the abundance and distribution of elements, high-energy physics, fibre bundles and differential geometry, methods of determination of steroids in blood and urine, specificity in development, and Lie groups and Lie algebras. Other conferences, symposia or meetings sponsored by the Foundation dealt with physics research in colleges, education in physiological science and the production and use of technical reports. Responsibility for maintaining a register of scientific and technical personnel in the United States was transferred from the Office of Education to the Foundation on January 1, 1953, and with financial assistance from the Foundation some ten to twelve scientific societies are setting up comprehensive registers which by June this year are expected to cover essential information on about a hundred thousand scientific workers and engineers. Registers for all main fields of science should be established by June 1955, and meanwhile information already collected is being analysed and reports are being prepared on specific scientific fields. The present report gives

* The Third Annual Report of the National Science Foundation. Year ending June 30, 1953. Pp. vii+110. (Washington, D.C.: Gov. Printing Office, 1953.) 40 cents.

an analysis of the type of employment of American scientists in 1951 and of their average annual salary. Of 1,320 who obtained the degree of Ph.D. in mathematics, 88·0 per cent went into educational institutions, 6·1 per cent into government service and 5·9 per cent went into industry. For other subjects the statistics relate to Ph.D.'s and B.Sc.'s and are interesting in that the figures for the latter show a marked preponderance for industry as against educational institutes. The numbers, with the percentages going to educational institutes, government service and industry shown in brackets, are as follows: chemistry Ph.D.'s 11,568 (32·5, 7·4, 60·1) and B.Sc.'s 25,086 (4·8, 8·6, 86·6); chemical engineering Ph.D.'s 854 (30·1, 2·7, 67·2) and B.Sc.'s 8,251 (0·7, 4·1, 95·2); and physics Ph.D.'s 2,784 (58·4, 10·7, 30·9) and B.Sc.'s 1,365 (21·4, 23·9, 54·7). Average annual salaries were highest for graduates in chemical engineering; they were about equal for graduates in chemistry and in physics, with mathematics and psychology appreciably lower and approximately equal. Except for physics, where salaries in Government service and in industry, at least at the doctorate level, tended to be equal, average salaries were highest in industry and lowest in educational institutions.

During the year the Foundation made 173 grants totalling 1,698,150 dollars for the support of basic research in the biological, medical, mathematical, physical and engineering sciences at 85 institutions. Seventy-two of these grants, totalling 798,800 dollars, were for biological and medical research, and a hundred, totalling 866,550 dollars, were for research in the physical, mathematical and engineering sciences, chemistry (28 totalling 206,500 dollars) and physics (22, totalling 282,400 dollars) receiving the greater part. The conference on physics research in colleges, already noted, recommended that, in evaluating proposals, besides the intrinsic significance of the proposed research, emphasis should be placed on the probable value of the project to the educational work of the institution. It was also suggested that projects which involve the participation of students should be encouraged and that due weight should be given to the promise and ability of the principal investigator.

In further illustration of the Foundation's understanding of basic research, the report gives a number of examples of investigations currently supported. Of the type involving observation and description are B. Maguire's exploration of the botanical resources of the Guayana Highland of British Guiana, S. D. Durrant's study of mammals on the Aquarius Plateau in the Henry and Abajo Mountains of Southern Utah, and T. H. Bullock's study of the pit organ of pit vipers. Among investigations concerned with the development of tools and instruments are M. Jakob's study of bubble formation, heat flow and other aspects of boiling, explorations of the upper atmosphere at the Ionosphere Research Laboratory, Pennsylvania State College, and the construction and operation of a radio telescope at Harvard College Observatory, under the direction of B. J. Bok. In the field of measurement, grants have been given for investigations of an unchanged component of cosmic radiation called *N*-rays, believed to be mostly high-energy neutrons. Several research projects which involve the design of suitable models for dealing with difficult problems were also being supported: these include a laboratory model of the photosynthesis of sugar and cellulose and of the biochemical reactions responsible for the luminescence of fireflies. Grants for the development of concepts include one for the development of a new conceptual basis for probability, and those for testing concepts include a grant to study regeneration of tissue (particularly to attempt to find a growth-inhibiting substance in the adult tissue) and one to test the assumption that cosmic radiation has been constant during the past thirty thousand years by measuring the radioactive carbon content in sediments at the bottom of the ocean.

Of the 557 fellowships awarded for the academic year 1953–54, 42 were made to post-doctoral candidates and 175 to those who had received awards in 1952–53; 180 went to first-year graduate students, 166 to those in their second year, and 169 to those in their final pre-doctorate year. Chemistry claimed 129 fellowships, physics and astronomy 115, engineering 63, mathematics 56, zoology 38, biochemistry 35, geosciences 26, botany 19, microbiology 18, geophysics 14, medical sciences 14, genetics 11, psychology and anthropology 10, and agriculture 9. In view of the increasing number of applications (3,300 as against 3,000 in 1952–53) the Foundation published an 'honourable mention list' of 1,274 applicants.

During the five years 1948–52, bachelor's degrees in science, engineering and agriculture totalled about 95,000 a year, and doctor's degrees in the same fields 4,660; for 1953–57 the comparable estimates are 66,800 and 5,420, respectively; but it is expected that the downward trend will be reflected in doctorate awards from 1956 onwards. Graduate enrolment at the first year in all fields of science fell from about 12,000 during 1951–52 to about 8,000 during 1952–53. So far, the Foundation has not asked Congress for funds to support a scholarship programme but is attempting to increase the supply of young scientific workers by improving the teaching of science. The Foundation has also established an Advisory Panel on Scientific Information, and preliminary inquiry suggests that the most important information in unclassified research reports reaches scientific workers through established publication channels.

ROYAL SCOTTISH FORESTRY SOCIETY

CENTENARY VOLUME

THE Royal Scottish Forestry Society is the oldest forestry society in Great Britain (the English Society having been founded in 1881), and this year it is celebrating its centenary. In honour of the occasion, the Society proposes to issue four special numbers of its journal, *Scottish Forestry*, as a centenary volume, each number containing three articles which will deal with all the aspects of forestry, and the first of these numbers has recently been published (*Scot. For.*, **8**, No. 1; January 1954). It opens with centenary greetings from the president of the Society and of the English Society, the chairman of the Forestry Commission, Lord Radnor, the chairman of the Empire Forestry Association, and the president of the Society of Foresters of Great Britain, and then goes on to the three articles: the history and activities of the Society, 1854–1953, by the honorary secretary of the Society, Sir Samuel Strang Steel; forest policy and legislation affecting Scotland, 1854–1953, by Sir Henry Beresford Pierce,

of the Forestry Commission; and private forestry in Scotland, by Sir John Milne Home.

The first article recalls how the original president of the Society was James Brown, at that time deputy surveyor of the Forest of Dean and provisional head forester of Armiston, who is chiefly known as the author of "The Forester", the standard book on forestry at that period. The Society was formed by a strong committee of nineteen which framed its constitution and its by-laws, subscriptions and so forth. Members were soon forthcoming, and the first *Transactions* of the Scottish Arboricultural Society, as it was then called, appeared four years later. During the past century the Society was constantly pressing the claims of forestry in Scotland on the Government, and committees and commissions were appointed by the House of Commons, without, however, much practical result until the present century.

In Sir Henry Beresford Pierce's well-informed article he points out that it was the Society (and, in particular, Munro Fergusson, afterwards Lord Novar, Sir John Sterling Maxwell and Lord Lovat) which pressed the Government to form a model State forest to be a pilot scheme to a much larger proposal that the Society put forward, namely, the afforestation of between three and four million acres in Scotland. As a practical outcome of this suggestion, the Royal Commission on Coast Erosion in 1909 proposed alternative schemes for the afforestation of nine million or six million acres in the United Kingdom. It was the First World War which eventually brought these ultimative schemes to a head in the Acland Report and the Government Bill forming the Forestry Commission at the close of the War.

The Society may be congratulated on the proposed centenary volume, for in that should be assembled the true forestry history of the period and the ideas which make for an appreciation of what forests and forestry really imply to a country and its people.

E. P. Stebbing

ADAPTIVE CHANGES IN SUNFLOWER

G. E. BLACKMAN AND G. L. WILSON have continued their physiological and ecological analyses of plant environment by investigating the adaptive changes in the vegetative growth and development of *Helianthus annuus* as induced by alterations in light-level (*Ann. Bot.*, 18, No. 69, 71; 1954). To this end pot experiments were carried out in which sunflowers in the early vegetative phase were first grown for a period under three levels of light (1·0, 0·5 and 0·24 daylight). Afterwards, pots from each light-group were subdivided into three so that in a second period plants could be subjected to the nine possible combinations of the same three light-intensities before and after transference. During the post-transference period of adaptation to either a higher or a lower intensity the net assimilation-rate was found to be logarithmically proportional to the light received and there was no residual effect of the initial light treatments. Eight days after transference the leaf-area ratios (total leaf area/total plant weight) at each light-level became adjusted to a new equilibrium irrespective of the large initial differences in the ratio induced by the pre-transference intensities. In both periods there was an inverse and logarithmic relationship between the leaf-area ratio and falling light-intensity; consequently, the greater the degree of shading in the pre-transference period, the higher were the mean ratios in the second period. Since the relative growth-rate is the product of the net assimilation-rate and the leaf-area ratio, the variations in the leaf-area ratio in the post-transference period induced by the initial light treatments were reflected in the relative growth-rates. Thus plants transferred from a lower to a higher light-intensity were leafier and initially grew faster than plants maintained at the higher level in both periods: the converse conditions led to a reduction in the growth-rate.

It was observed that shading depresses the growth of the roots, but that the relative growth-rate is dependent on the light-intensity in both the pre-transference and post-transference periods. The growth-rate was maximal when plants were moved from the lowest to the highest intensity.

In terms of leaf weight, decreasing the light-intensity decreased the relative growth-rate and there was no consistent after-effect of the initial light treatments. The rate of expansion in leaf area tends to be highest at the intermediate level of 0·5 daylight, and over all the post-transference intensities the rates were maximal for those plants which received initially full daylight. The ratio of leaf area to leaf weight was inversely and logarithmically proportional to the light-level. After transference, the slopes of the regressions were independent of the initial light treatments; but the mean ratios were inversely correlated with the initial degree of shading. These observations are discussed with particular reference to the control of growth exerted by growth-regulating substances: on the basis of existing knowledge, no adequate interpretation of the adaptive changes yet seems possible.

DISTRIBUTION OF LAMINARIACEAE AROUND SCOTLAND

By F. T. WALKER

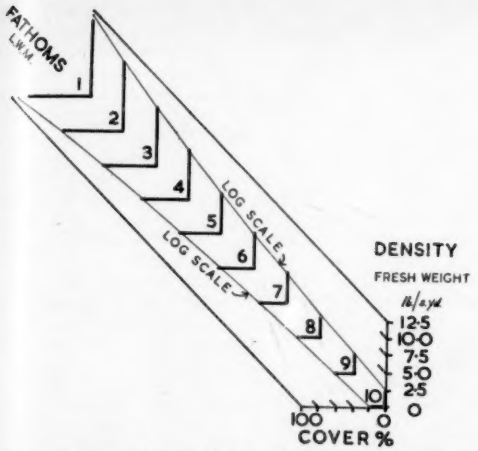
Institute of Seaweed Research, Musselburgh, Midlothian

FIFTY-NINE detailed surveys, covering 80,000 acres of the sub-littoral zone off the north-east, south-east and south-west mainland of Scotland, the Isle of Skye and several of the islands of Orkney, have been completed by the Botanical Division of the Institute of Seaweed Research.

The detailed surveys were preceded by aerial photogrammetric surveys. They were carried out at all times of the year and during seven years, 1946–53, and so include seasonal and cyclic changes. They covered areas of the sea-bed from low-water mark down to ten fathoms (19 m.), where the dominant species was either *Laminaria cloustoni*, *L. digitata* or *L. saccharina*. (Some surveys were restricted to depths of 1–6 fathoms.) Tidal streams ranged from 0 to 7 knots and tides from low-water mark to 3 fathoms (6 m.) according to time and location.

In the course of the fifty-nine surveys, operated from motor-vessels, some 50,000 quadrats were taken from the sea-bed by means of calibrated spring-grabs which close by trigger action on reaching the bottom[1].

The 1946–49 surveys employed methods of quadrat sampling along transects measured by range-finder,



The master means of fresh weight (vertical lines) and percentage cover (horizontal lines) of Laminariaceae found at 1–10 fathoms low-water mark ordinary spring tides, from the data of 59 surveys around Scotland between May 1946 and September 1953

while for the 1949–53 surveys, random sampling was used. Random sampling is less dangerous inshore; nevertheless, this method can attain considerable accuracy: standard errors of 1–2 per cent of the mean, when the intensity of sampling is only 100 quadrats per square kilometre, have been achieved.

The mean of the means (which we term the master mean) of 'density' and 'cover' found at each depth for the fifty-nine surveys is given in Table 1 and in the accompanying figure.

Density is the average fresh weight of *Laminariae* per unit area based on quadrats which contained these algae. Cover is the number of quadrats which contained *Laminariae* expressed as a percentage of all quadrats.

From the above data, several conclusions may be drawn. First, it will be found that the value for density divided by the respective value for cover is a good approximation to a constant (13·14) for each fathom interval of depth of 1–10 fathoms. The density/cover values for the ten depths have a standard deviation of 0·9 and a standard error of 2 per cent from the constant. The fresh weight of *Laminariae* is therefore proportional to the percentage cover. This relationship has been reported for many individual surveys[2–5].

Secondly, the seaweed densities given in Table 1 follow an exponential scale. The regression of this scale with increasing depth calculated on $\log_{10}$ is 1·1600–0·0770 per fathom, from 1 to 10 fathoms, low-water mark ordinary spring tides. As the cover

Table 1

Depth Low-water mark ordinary spring tides (fathoms)	Density Master mean of 59 surveys (based on quadrats with *Laminariae*) (lb./sq. yd.)	(kgm./sq. m.)	Cover Master mean of 59 surveys (per cent)
1	11·0	6·0	76
2	10·3	5·6	72
3	8·8	4·8	65
4	7·5	4·1	57
5	6·2	3·3	48
6	5·3	2·9	44
7	4·7	2·5	35
8	3·3	1·8	28
9	2·7	1·5	21
10	2·3	1·2	18

Table 2

Depth Low-water mark ordinary spring tides (fathoms)	Cover Master mean of 28 surveys (per cent)	Standard deviation of mean density Master mean of 28 surveys	Standard deviation Cover
1	68	5·20	7·6
2	65	4·73	7·3
3	58	4·30	7·4
4	51	3·63	7·1
5	45	3·07	6·8
6	39	2·43	6·2

is proportional to the density, then the cover must be exponential also with depth.

Seaweed growth is the result of photosynthesis. If light be the limiting factor we would expect the growth of *Laminariae* to be exponential with increasing depth, for the coefficient of extinction of the visible solar spectrum is also logarithmic through water.

The 'coefficient of extinction of *Laminariae*', based on the exponential scale $\log_e$, equals 0·096 per metre interval of depth.

The area covered by the species of *Laminariae* has been shown above to be proportional to the density or fresh weight at various depths; cover, then, should be proportional to the standard deviation of the mean density where the frequency and the spread of the quadrat weights follow normal distributions.

The standard deviation of the mean density has been calculated for twenty-eight of the surveys, carried out between 1949 and 1953, when random sampling was employed. The master means against the corresponding values for cover are given in Table 2 from 1 to 6 fathoms.

It will be found that the values in Table 2, col. 4, equate as follows: standard deviation of the mean divided by the percentage cover equals 8·1–0·3 fathom (± 3 per cent), or the standard deviation is closely proportional to the cover. From this it may be concluded that the algal cover is conditioned by the frequency and spread of the algae, which in turn are the result of photosynthesis–reproduction–dispersion; while the nature of the substrate plays an important part in the establishment of algae, the areas under review were selected because they did support prolific laminarian growth.

In more recent surveys the number of plants per quadrat has been recorded, and the decrease in seaweed density has been found to be more the result of a reduction in the number of plants per unit area than of the weight of individual plants. It follows that with increasing depth the total spore production will be decreased, dispersion and fertilization will be restricted and the plant cover limited.

This last conclusion requires the development of the spores to proceed at approximately the same depth of sea as that at which the parent plant is or was growing.

Time has been available for the analysis of only a limited number of surveys by the application of the chi-squared test to samples and their distributions. The data of some surveys fit normal distributions admirably, others do not. For example, a survey carried out between Girvan and Bennane Head in the approaches of the Firth of Clyde during May 1952 indicated that the frequency and spread of the samples had a normal distribution at all depths from 0 to 6 fathoms. An identical survey, carried out in the following October–November after severe gales had

reduced the total quantity of seaweed by more than 34 per cent, showed the samples no longer conformed to normal distributions when the χ^2 test was applied.

The aerial survey of the sub-littoral zone of Scotland (begun in 1945) in conjunction with the results of the detailed surveys have enabled me to assess the total laminarian growth from aerial photographs taken by the Royal Air Force, to which grateful acknowledgment is made for its co-operation.

The first assessment was made in 1950, and a reassessment in 1954 shows no extensive changes, although it is now known that cyclic changes are occurring. These will be reported later.

The marine coast of Scotland and Islands is 5,300 miles; the sub-littoral zone from low-water mark to a depth of ten fathoms is two million acres; over this area, with considerable variation in seaweed density, grows 10 million tons (fresh weight) of Laminariaceae. Of this quantity, 3–4 million tons are concentrated in quantities of economic value.

[Jan. 18.

[1] Walker, F. T., *J. Ecol.*, **35**, 166 (1947).
[2] Walker, F. T., *Nature*, **161**, 977 (1948).
[3] Walker, F. T., *J. Ecol.*, **38**, 139 (1950).
[4] Walker, F. T., *J. Ecol.*, **40**, 74 (1953).
[5] Walker, F. T., and Richardson, W. D. (presented for publication).

UPTAKE OF RADIOACTIVE CARBON AND PHOSPHORUS BY PARASITIZED LEAVES

By Dr. M. SHAW
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and
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THE arbitrary nature of the distinction between 'obligate' and 'facultative' parasites on plants has long been recognized, as well as the possibility that advances in knowledge might lead to the successful culture of the former, including rusts and mildews, on artificial media[1]. Indeed, this has apparently now been accomplished in the case of *Gymnosporangium juniperivirgianae* Schw., a rust producing telial galls on *Juniperus*[2]. Nevertheless, relatively little is known about the physiology of rusts and mildews and their effects on host metabolism, or of the physiological basis of resistance to them. Both obligate and facultative parasites cause marked increases in the respiration of the host tissues, even at considerable distances in advance of the invading mycelium, a phenomenon which may be attributed to the production of diffusible substances by one or both members of the host–parasite complex[3]. Eventually photosynthesis is reduced, and there is usually a visible chlorosis in the area of infection. An outstanding characteristic of rusts and mildews on cereals is that increased respiration[4] and decreased photosynthesis are accompanied, in the earlier stages of disease, by increases in hexose, sucrose, starch[5], free amino-acids[6] and, to judge from the occurrence of oil droplets, possibly in lipid content as well. Often the only starch to be found in the mesophyll of wheat leaves occurs as a deposit around infections of these fungi. Under optimum conditions, the host tissue at infection sites flourishes long after the remainder of the leaf is moribund, and there may even be a resynthesis of chlorophyll[5], leading to the formation of the characteristic 'green islands'.

Gottlieb and Garner[7] demonstrated the movement of phosphorus-32, supplied to the culture solution as phosphate, to infections of *P. graminis* on wheat. In their experiments the plants were exposed to the isotope for several days. The specific activity of the uredospores was less than that of either healthy or infected leaf tissue. Yarwood and Jacobson[8] described the preferential absorption of sulphur vapour by infections of *Uromyces phaseoli* on bean and sunflower and *Erisyphe polygoni* on bean after eight-hour exposures to sulphur-35. The treatment was lethal to the fungi but did not damage the leaves.

The isotope technique appeared to offer an approach to the investigation of the relation between diseased and healthy tissue on the same leaf. Accordingly, we examined the effect of infection with a number of facultative and obligate parasites as well as of mechanical wounding on the distribution of phosphorus-32, supplied as phosphate, and of carbon-14, fed to the leaves as carbon-14 dioxide or sugars (glucose-1 ^{14}C, ribose-1 ^{14}C, xylose-1 ^{14}C) under a variety of conditions. The sugars and phosphate were introduced either by localized injection of attached leaves or by standing the cut-leaf bases in 0·25 per cent (w/v) solutions in distilled water or phthalate buffer at *p*H 5·5 for from 20 min. up to 24 hr. The leaves were then killed between hot metal plates, pressed and autoradiographs prepared using Kodak No-Screen X-ray film.

In uninfected leaves fed with labelled sugars or phosphate, tissue wounded by pricking or removing the epidermis was sometimes as active as that in undamaged areas, but usually less so. No tracers entered areas which were actually dead. Similarly, no activity entered or accumulated around the lesions produced on *Vicia faba* by *Botrytis* sp., which kills the host tissue in advance. Moderate accumulation was observed in young infections and around, but not within, older infections of *Pseudomonas medicaginis* f. sp. *phaseolicola* (Burkholder) Dowson, on *Phaseolus vulgaris*. There was no accumulation in young infections of *Helminthosporium* sp. on wheat and actually less radioactivity (from glucose) in young lesions produced on oats by *Pseudomonas coronafaciens* (Elliott) Stapp than in surrounding healthy tissue. After 20 hr. a diffuse zone of increased activity was observed around old, large, lesions of *Helminthosporium* on wheat, as at the edges of cuts made transversely across the lamina. In short, the results obtained with these facultative parasites showed a general similarity to those obtained by the mechanical wounding of healthy tissue. It is clear, however, that the range of facultative parasites investigated should be extended to include types more closely approaching obligates in their behaviour.

The results obtained with rust (*P. graminis* on wheat and barley and *P. helianthi* on sunflower) and mildew (*Erisyphe graminis* on wheat and barley) were more striking than those described above. From an early stage (3–4 days after inoculation) of development on susceptible hosts, there was a rapid and marked accumulation of radioactivity at infections of these obligate parasites, as illustrated in Figs. 1–2

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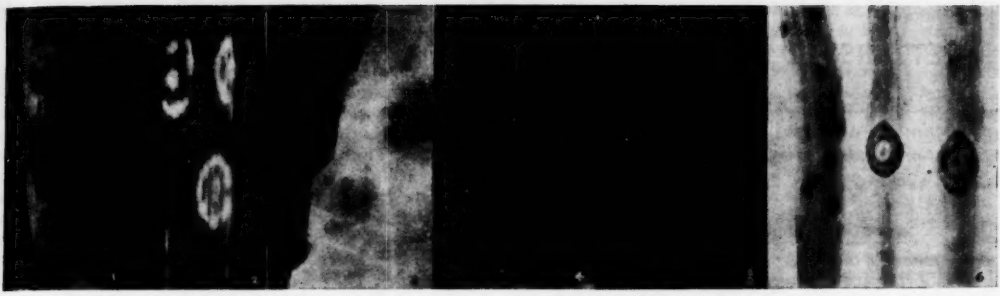

Figs. 1–2. Autoradiographs of excised wheat leaves with 12-day old infections of *P. graminis*. At this stage of development the starch deposit lies outside the secondary uredinia (see Fig. 6). (1) After feeding 0·25 per cent xylose-1 ^{14}C for 45 min. (2) After 165 min.; the activity is concentrated beneath the uredinia. In all figures light areas indicate high activity

Figs. 3–5. Autoradiographs of sunflower leaves, bearing 8-day old infections of *P. helianthi*, exposed to carbon-14 dioxide for 3 min. at a light intensity of 500 f.c. Total concentration of carbon dioxide approximately 0·03 per cent. (3) Killed immediately. (4) Killed after standing in a normal atmosphere for 20 min. (5) Killed after 4½ hr.

Fig. 6. Starch formation in wheat leaves infected with *P. graminis*. The leaves were cleared in alcohol and stained in aqueous iodine

for *P. graminis* on wheat. Identical results were obtained with glucose, ribose and xylose and phosphorus-32. Following exposures to carbon-14 dioxide in the light for 0·5–3 min., leaves were killed immediately, and also after standing in a normal atmosphere for varying periods of time. Autoradiographs revealed the effect of the parasite in depressing photosynthesis in the invaded host tissue and the subsequent influx of fixed carbon-14. A typical result is shown in Figs. 3–5 for *P. helianthi* on sunflower.

By removal of the ectoparasitic mycelium of mildew both before and after exposure to the isotopes, it was possible to demonstrate that the bulk of the accumulated activity was in the mesophyll of the host, beneath the fungal mycelium. Moreover, accumulation was not detectably impaired by removal of the mycelium prior to the experimental treatment. The 'active' nature of the process is emphasized by the results of preliminary experiments with both rust and mildew in which marked inhibition was obtained with phloridzin (1 m*M*) and dinitrophenol (1 m*M*) in phthalate buffer[9] at *p*H 5·5. Little inhibition was observed with azide (10 m*M*) under these conditions. Allen and Goddard[10] reported that the mildew-stimulated respiration of wheat was insensitive to azide, which did, however, inhibit the respiration of the fungus itself.

Accumulation was much more pronounced with susceptible- than with resistant-type infections of rust and mildew. This cannot be regarded merely as an expression of the degree of utilization of substrate by the parasite, since the increase in activity is mainly in the mesophyll of the host. Similarly, under summer greenhouse conditions starch was deposited in association with susceptible but not with resistant infection types. Even with the former, no starch formed under winter greenhouse conditions at Saskatoon. Starch formation, formerly attributed to a breakdown in translocation[11], is probably also the result of translocation to the infection. An interesting point is that, in the case of rust, the starch is deposited as a very distinct ring. In young infections this closely surrounds the uredinia but later becomes separated from them by a starch-free zone (Fig. 6).

It is essential for successful obligate parasitism that substrates be supplied to the invaded cells at a rate high enough to maintain their organization and metabolism in the presence of the parasite, which cannot exist on dead tissue. Whether or not the parasite obtains an adequate supply of substrate for continued growth must depend on the relative rates of utilization and supply (transport) of substrate. It may be imagined that in resistant hosts the latter limits the growth of the fungus initially, and that subsequent exhaustion of the invaded host cells and suboptimal nutrition of the fungus result in the formation of metabolic products, by one or both members of the complex, which would not otherwise be formed in critical amounts. These may well be toxic to either or both parasite and host. Injury to the invaded host cells may also stop all translocation to and from surrounding healthy areas, as is the case with at least some facultative parasites. A parasite-induced increase of permeability of the type reported by Thatcher[12] does not appear capable of explaining the active transport described here.

Our observations support the hypothesis that a substance (or substances) diffusing from the site of infection alters the normal metabolism of the host tissue. The concentration of this substance, as controlled by rates of production, breakdown or inactivation, and diffusibility, may be regarded as governing the rate at which metabolites move into the infection from surrounding areas and thus the supply of substrate to both parasite and parasitized cells. It seems apparent that the rate of movement of substrates both toward and away from the primary infection must play an important part in determining susceptibility to disease, at least in the case of obligate parasites.

These observations, which will be published in detail elsewhere, form part of a programme of research on the physiology of parasitism financed by grants (to M. S.) from the Department of Agriculture and the National Research Council. We are grateful to Dr. A. C. Neish for providing the labelled sugars, to Prof. J. W. T. Spinks for a gift of phosphorus-32, and to Dr. W. A. F. Hagborg for cultures of the bacterial pathogens. [Dec. 31.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Science Teachers in Schools

As a member of the Appleton Committee considering the shortage of teachers of science and mathematics in Scotland, I have read with very great interest the editorial comments in *Nature* of January 30, p. 177. I have found the comments of great interest and value. There is, however, one small passage of which the implication is not too clear. The passage in question states: "Are not these small science sixth forms due partly to the fact that some of the science teachers are of such moderate ability and personality that they cannot attract any more pupils to their side of the school, and partly to the fact that, where the teacher is competent, he has already attracted all the pupils capable of doing sixth-form science?"

Surely the two possibilities visualized here are rather contradictory. In one case it suggests that the smallness of the science classes is due to incompetence on the part of the science teachers. If this is the case, the obvious solution is to improve the quality of the science teachers. If, however, the second possibility is true, improvement of the quality of the science teachers would be of no avail. However competent the science teacher he cannot teach the subject to pupils incapable of absorbing it, and the problem is impossible of solution. After all, you cannot make a silk purse out of a sow's ear. I may, however, have misunderstood the implication of this passage.

I also note that the National Advisory Council suggests that "the glamour of research should be counteracted by putting the case for teaching as a satisfying career to undergraduates in the pure science departments of the universities". While I agree that too many unsuitable people are attracted by the glamour of research, I am appalled by the suggestion that those responsible for advising undergraduates should be expected to pretend that teaching is a satisfying career if this is not in fact the case.

In Scotland, great emphasis is laid upon the desirability of science teachers holding first- or second-class honours. While agreeing that teachers should be of the best quality, I cannot agree that the holder of first- or second-class honours is likely to be a better teacher than a man holding a good pass degree. In fact, I feel that the honours man tends to be a narrow specialist, whereas a schoolmaster should be a man of broad general culture. It is surely not necessary to hold a first- or second-class mathematics degree to teach quadratic equations. I have been assured by a professor of mathematics in a Scottish university that it is the realization that they will not use their academic knowledge to the full which creates a reluctance of honours graduates to go in for teaching.

In conclusion, I should like to say that I heartily agree with the last paragraph of the article. Legislation on education of the past twenty years or so has been too much the prey of the popularity-seeking politician.

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Nature's campaign to promote action on the part of the various authorities concerned with the future of science and science teaching is admirably persistent and constructive. One of the suggestions (*Nature* of February 27, p. 368) is of particular interest. It reads as follows: "If more of the graduates in arts, for example, left the universities of Britain with some sound knowledge of general science, they might well be qualified to assist in the general science teaching which is so desirable for the ordinary citizen, whether or not he proceeds beyond the grammar school or technical school level". This is an admirable idea which I should be delighted to see carried out as an educational policy; but it is well to examine the difficulties that lie in the way to see if they can be surmounted.

First of all, let us take a historical fact. More than thirty years ago, in one university at least, intending teachers entering the faculty of arts were compelled to take either mathematics or science as part of their studies if they had not included Latin in their matriculation. The result was not happy for those taking compulsory science. Lecturers and demonstrators were not particularly interested in students who were pursuing subjects that were regarded as makeweight. The students themselves felt they were intruders or 'poor whites'. The scheme was not continued. It would be folly to make further attempts along the same lines.

Secondly, let us deal with general science—an admirable conception, rarely if ever realized. If general science is ever to become, what it should become, the peer of English as the main educational discipline for children of school age, the organization will have to start in the universities; but this will need men and women imbued with the fervour and enthusiasm of a T. H. Huxley. It will need in its pioneers a combination of humanist, philosopher and scientist, together with willingness to sacrifice possible fame as scientific discoverer to the more humble reputation of teacher. If such a discipline could be instituted to reach down from the universities to the schools and outwards from the schools to all human activities, it would, in the words of the article, facilitate "the absorption of science into the general culture . . . and it would also assist the graduate science teachers to concentrate more on the sixth forms or the teaching of those with a scientific career in mind". However, it is unlikely to succeed unless general science becomes as important in general esteem as particular scientific studies.

The arts graduate is already in danger of becoming a poor relation because the science graduate is attracting an inordinate proportion of special posts in the schools. This regrettable tendency to devaluate the arts degree is already having unhappy results and can lead only to ill-effects on our general culture.

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Solar Radio Asymmetry at 4-Metres Wave-length

In 1948, Hey, Parsons and Phillips[1] reported that at 4·1-metres wave-length bursts of radio emission, usually of a few minutes duration, occurred more often in association with flares on the eastern half of the sun's disk than on the western half. Subsequent observations have confirmed this conclusion. In a recent analysis of radio emissions at 1·5-metres wave-length, Dodson, Hedeman and Owren[2] could find no evidence of this asymmetry. The following reasons may explain why they failed to observe the effect.

Hey, Parsons and Phillips[1] suggested that the asymmetry they had observed might be due to radio absorption in ionized solar corpuscular streams, as the rotation of the sun causes the envelopes of such streams to drift eastwards relative to the active solar regions from which they emanate. They also pointed out that the longer the wave-length, λ, the greater would be the expected absorption. That this anticipated property provides a test of the absorption theory was emphasized by Unsöld and Chapman[3].

As the absorption coefficient is proportional to λ^2, it is approximately 7·5 times greater at $\lambda = 4{\cdot}1$ metres than at $\lambda = 1{\cdot}5$ metres. Further, if the electron density in the stream is sufficient, the refractive index, μ, may be appreciably less than unity at long wave-lengths, and the absorption coefficient would again be increased since it is inversely proportional to μ; in addition to this, refraction might be expected to diminish radio intensities in the direction of the ionized streams by deviating the long radio waves out from them. It is consequently to be expected, on the hypothesis that solar radio asymmetry at $\lambda = 4{\cdot}1$ metres is due to asymmetrical absorption in an ionized stream, that the asymmetry might be difficult to detect at the shorter wave-length of 1·5 metres. The results reported by Dodson, Hedeman and Owren are therefore in accordance with this hypothesis, although the conclusion can scarcely be regarded as decisive yet as they analysed only about two hundred flares with associated radio measurements during 1948–50, whereas we found that ten times this number of observations obtained during 1947–50 were only just sufficient to establish the significance of the asymmetry at $\lambda = 4{\cdot}1$ metres at the 5 per cent level of chance probability.

Additional data at $\lambda = 4{\cdot}1$ metres obtained during part of 1946 and the first half of 1951 have increased the significance of the asymmetry observed at this wave-length. It is unfortunate that, owing to interference and other circumstances, radio measurements had to be discontinued in 1951, because a striking feature is the pronounced increase in the asymmetry during the second half of 1950 and the first half of 1951, just when the recurrent *M*-type magnetic storms were becoming prominent. This suggests the intriguing possibility that continuous *M*-type corpuscular streams may be more effective in producing absorption than are the spasmodic bursts of corpuscular emission from active flare regions.

A detailed analysis of the radio asymmetry with respect to terrestrial magnetic activity is now in progress. It is hoped that this may be decisive in establishing whether or not the interpretation in terms of the absorption of a corpuscular stream is correct. There is so little direct evidence of solar corpuscular streams, and especially of the nature of solar *M*-regions, about which there is yet uncertainty whether the terrestrial magnetic activity might be due not to corpuscular streams but to ultra-violet radiation, that any evidence which can be derived from radio phenomena is of importance.

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this communication.

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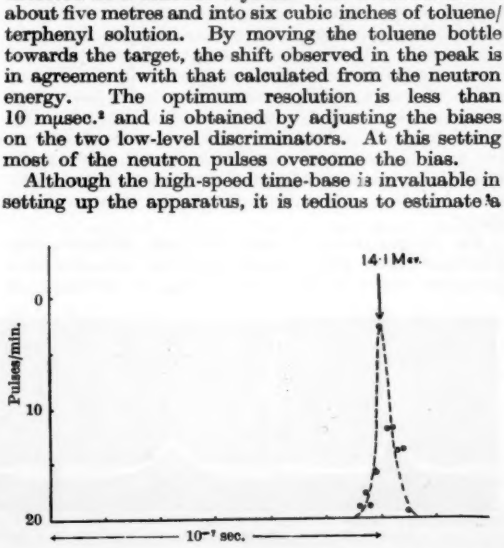
Time of Flight of 14·1-MeV. Neutrons

The essential problem in utilizing the time of flight of fast neutrons for energy measurements is the rapid fall-off in efficiency of detection as the flight path D is increased, since the resolution is proportional to D, while the efficiency is proportional to D^{-2}. It is therefore desirable that a multi-channel time spectrometer be used when a neutron momentum spectrum is being analysed.

One such instrument is the high-speed triggered oscilloscope in which the first pulse triggers off the time base and the second pulse is displayed on the 'y' plates. Using a new form of high-speed time base and low-level trigger circuit[1], the group of pulses due to the 14·1-MeV. neutrons from the reaction $^3H(d, n)^4He$ has been analysed. A full account of the technique will be published later; but it is felt that a preliminary indication of the feasibility of the method and indeed of the accuracy of the analysis even with such high-energy neutrons will be of interest. The graph shows the number of pulses falling in each division of the time base which is triggered from the recoil ^4He detected in a stilbene crystal. The neutrons travel about five metres and into six cubic inches of toluene/terphenyl solution. By moving the toluene bottle towards the target, the shift observed in the peak is in agreement with that calculated from the neutron energy. The optimum resolution is less than 10 mμsec.[2] and is obtained by adjusting the biases on the two low-level discriminators. At this setting most of the neutron pulses overcome the bias.

Although the high-speed time-base is invaluable in setting up the apparatus, it is tedious to estimate the



time distribution on it. An electronic circuit is therefore being developed to convert a time spectrum into a voltage spectrum, which will then be fed into a multi-channel kick-sorter.

I am indebted to Dr. P. J. Grant, Dr. J. G. Rutherglen and Mr. J. Fraser for their generous assistance in using the Glasgow University Physics Department high-tension set.

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A Proton Magnetic Resonance Study of the Hydration of Deoxyribonucleic Acid

Dilute solutions of deoxyribonucleic acid have high viscosity, very large increment of dielectric constant and high osmotic pressure. It has been suggested that these properties result from the formation of large hydration shells with a higher degree of lattice order than that prevailing in pure water[1]. In order to investigate these phenomena further, we have studied proton magnetic resonances of some deoxyribonucleic acid solutions and gels.

Two high polymeric preparations of sodium deoxyribonucleate (according to the method of Gulland *et al.*[2]) were investigated in concentrations of 0·06–60 per cent by weight. For comparison, 1·6 per cent solutions of hæmocyanin (*Helix pomatia*), soluble starch and egg albumin were also studied. Proton magnetic resonances were observed in a magnetic field of about 7,050 gauss with a resolution of three parts in 10^7. Resonances were displayed on the screen of an oscilloscope and photographed (Fig. 1), and the areas of the traces of the absorption mode were measured[3].

The normalized area measurements (col. 2 in Table 1) are representative of the fraction of the water protons which contributes to the signal within a line width of about 15 milligauss. The remaining fraction (col. 3) of the protons has a resonance line that is so broad that it does not contribute to the area measured. (The more concentrated solutions of deoxyribonucleic acid gave resonances the visible line width of which, while noticeably greater than that of pure water, was still less than 15 milligauss.) The broadening of the line may be due to several causes; the most likely in this case are increased order of the water lattice and exchange of protons or water molecules between ordered and disordered phases of the water.

For hæmocyanin, starch and egg albumin, the resonance lines were almost identical with the lines for pure water, and no broadening or decrease in area could be detected. This is to be expected since the degree of hydration of these substances is known to be low.

Table 1

Concentration (weight, per cent)	Area per gm. water in sample (arbitrary unit). Accuracy, ± 0·05	Fraction decrease of area*	Fraction decrease per conc. unit nucleic acid
Water	1·00	0	
0·06 per cent sodium deoxyribonucleate	0·94	0·06	1·0
0·6 per cent sodium deoxyribonucleate	0·83	0·17	0·28
1·6 per cent sodium deoxyribonucleate	0·69	0·31	0·19
60 per cent sodium deoxyribonucleate	0·15	0·85	0·014
0·06 per cent sodium deoxyribonucleate in 0·015 *N* NaCl	1·00	0	
1·6 per cent sodium deoxyribonucleate in 0·04 *N* NaCl	0·84	0·16	
1·6 per cent starch	0·99	0	
1·6 per cent hæmocyanin	1·0(5)	0	
1·6 per cent egg albumin	1·0(4)	0	

* Figure represents the fraction of the protons the resonance of which is very broad in comparison with 15 milligauss.

From the results for deoxyribonucleic acid, we conclude that in the hydration shells of the macromolecules there are some water molecules that have a higher degree of lattice order than that prevailing in pure water. The lattice order in the hydration shells is such that the resonances are broader than 15 milligauss. The observed line-width of pure water was 3 milligauss as determined by magnetic field inhomogeneities.

Since we do not know the amount of exchange broadening, if any, it is not possible to specify the exact size of the hydration shells from our present results. It is only possible to make the following quantitative statements. First, not less than the fraction indicated in col. 2 exists in a phase of sufficient disorder such that the lines are sharp compared to a solid phase such as ice. Secondly, the exchange, if any, between ordered and disordered phases must take more than 0·05 sec.

In principle, line-broadening could arise from a proton exchange between the water and the protons of the macromolecules. However, this effect cannot cause the main decrease in area, since there are not enough macromolecular protons present in the dilute solutions to make possible such a process. Furthermore, col. 4 indicates that an increase in concentration of nucleic acid does not result in a proportionate decrease in area.

On the addition of electrolytes to the nucleic acid solutions, considerable amounts of water previously bound are released to the normal water state, as shown by the larger values for normalized area shown in the table. This agrees well with the results obtained from dielectric, viscosity and osmotic pressure studies, which indicate that the ordering action of the macromolecules on the water lattice is much reduced in the presence of small amounts of electrolytes. This decrease in hydration is attributed to a contraction of the macromolecules leading to an impairment of the structural fit between the macromolecular surface and the regular

Oscillographic traces for (*a*) pure water, (*b*) 1·6 per cent sodium deoxyribonucleate, and (*c*) 1·6 per cent sodium deoxyribonucleate in 0·04 *N* sodium chloride

four-co-ordinated water lattice[1]. The proton magnetic resonance data support these ideas.

The dielectric method for studying water structure changes induced by macromolecules is more sensitive than the proton magnetic resonance technique. However, dielectric studies cannot be applied to solutions of high conductivity, whereas the proton magnetic resonance method is undisturbed by the presence of moderate amounts of electrolytes. This makes it possible to use the latter method for studies *in vivo*.

We wish to express our gratitude to Prof. Felix Bloch for helpful discussions, and to Dr. L. G. Allgen, Karolinska Institutet, Stockholm, for supplying one of the nucleic acid preparations.

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Synthesis of L-Amino-succinimide

IN an attempt to account for the differences in the chemical and physiological properties of asparagine and glutamine, Steward and Thompson[1] have suggested that the structure of asparagine is best described by a tautomeric system the major component of which is the monohydrate of amino-succinimide, while glutamine is best represented by the conventional straight-chain formulation. This theory has been questioned by Leach and Lindley[2], by Katz, Pasternak and Corey[3], and by others. Steward and Thompson[4] pointed out that the synthesis of amino-succinimide and a comparison of its properties in aqueous solution with a solution of asparagine would provide unequivocal evidence either for or against their hypothesis. We wish to report the synthesis of L-amino-succinimide.

In connexion with another investigation, we observed that the attempted saponification, under mild conditions, of carbobenzoxy-L-asparagine methyl ester[5] does not yield carbobenzoxy-L-asparagine. Instead the major product is a much weaker acid which we identified as carbobenzoxy-L-amino-succinimide, m.p. 79–81°, $pK_a = 9{\cdot}1$ in aqueous methanol, $[\alpha]_D^{24} - 43°$ (*c*. 1, 95 per cent ethanol); (calc. for $C_{12}H_{12}N_2O_4$: C, 58·05; H, 4·87; N, 11·29; amide-N: 5·65; found: C, 57·29; H, 5·17; N, 11·25; amide-N, 5·50 per cent). Carbobenzoxy-L-amino-succinimide is also obtained from carbobenzoxy-L-*iso*asparagine methyl ester. Reaction of the imide with aqueous ammonia yields carbobenzoxy-aspartic acid diamide. Prolonged treatment of the imide with alkali at room temperature, followed by hydrogenolysis to remove the carbobenzoxy group, results in the formation of a mixture of asparagine and *iso*asparagine.

Hydrogenolysis of carbobenzoxy-L-amino-succinimide yields L-amino-succinimide, m.p. approximately 144° (decomp.), $[\alpha]_D^{24} - 77°$ (*c*. 1, methanol); (calc. for $C_4H_6N_2O_2$: C, 42·10; H, 5·30; N, 24·6; neut. equiv. 114; found: C, 42·34; H, 5·28; N, 24·85 per cent; neut. equiv. 118 (titrated with acid)). Although L-amino-succinimide appears to be quite stable in the crystalline form, the compound is almost completely destroyed when a 1 per cent solution in phosphate buffer of *p*H 7·0 is heated for fourteen hours at 37°. Electrometric titration of an aqueous solution of L-amino-succinimide shows the presence of a weakly acidic group with $pK_a = 9{\cdot}0$, the imide-group, and a weakly basic group with $pK_a = 5{\cdot}9$, the amino-group. A mixture of L-asparagine and L-amino-succinimide can be separated readily by chromatography either with *n*-butanol–acetic acid–water (4 : 1 : 5) or with phenol saturated with water. It is thus clear that the properties of aqueous solutions of L-amino-succinimide and L-asparagine are not similar.

Details of these investigations are being published elsewhere[6].

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IN our earlier consideration of the relationships of asparagine and glutamine, substances which are of great physiological importance, we directed attention to the interest which would be aroused by an unequivocal synthesis of amino-succinimide and whether "it proved to be, when hydrated, identical or different from asparagine"[1,2].

Through the courtesy of Drs. Sondheimer and Holley, we have seen their paper[3] and communication (above) on L-amino-succinimide in advance of their publication. They are to be congratulated on what appears to be an elegant piece of synthetic work leading to derivatives of L-amino-succinimide and to the pure substance, the properties of which are now described for the first time.

It is of great interest to us that the substance amino-succinimide: (*a*) is stable in its crystalline anhydrous form; (*b*) can exist in aqueous solution and show by its titration curve the weakly acidic imide group and a weakly basic amino-group; (*c*) is distinguishable from L-asparagine by its position on chromatograms, though, like that substance, it reacts brown with ninhydrin on paper; (*d*) is readily convertible, even by warming to 37° at *p*H 7·0, to a mixture of asparagine and *iso*asparagine.

It is also of interest that in two ways, referred to by Sondheimer and Holley, there is a ready interconvertibility of the straight-chain form as it is supposed to occur in asparagine and the ring form as it occurs in amino-succinimide. This is shown by: (*a*) the hydrolysis of the methyl ester of carbobenzoxy asparagine yielding only carbobenzoxyamino-succinimide; (*b*) the combination of amino-succinimide with water to give asparagine and *iso*asparagine.

It is granted that the evidence of Sondheimer and Holley now is that asparagine and amino-succinimide can be distinguished. The important part of their evidence, in our view, is that which describes the properties of amino-succinimide in the free state and in solution. Apparently, amino-succinimide can exist unhydrated and distinguishable from asparagine, and when it com-

bines with water, which it does very readily at 37° or above, it gives not asparagine only but *both* asparagine and *iso*asparagine. While we are grateful to Drs. Sondheimer and Holley for furnishing evidence of the kind which we ourselves would have been glad to obtain, there still remain some features of the asparagine–glutamine problem that require explanation.

Asparagine and glutamine behave differently toward ninhydrin and they also behave differently toward nitrous acid in acetic acid solution. Asparagine reacts toward ninhydrin in two distinct ways. In solution in the cold or on paper at 60° C., it reacts with ninhydrin without being decarboxylated to form a brown compound. This reaction is typical neither of the α-amino-acids nor of glutamine. (In respect to the brown ninhydrin colour, asparagine resembles amino-succinimide more than glutamine.) In hot solutions, however, asparagine, like glutamine, may be made to react with ninhydrin with decarboxylation to give a blue colour and in a manner which is typical of most α-amino-acids. In the reaction with nitrous acid, the amide group of asparagine does not react, whereas that of glutamine does.

These anomalies and interesting physiological differences between glutamine and asparagine still require to be fully explained—even though, from the work of Sondheimer and Holley, one cannot now regard L-asparagine as a simple hydrate of L-amino-succinimide.

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Hydrogen Bonding and the Volume of Water

Water behaves approximately as a normal liquid with respect to its volume at a high temperature and pressure. The expected volume of the liquid at room temperature is obtained by extrapolation, for example, using the formula of Jacobson and Heedman[1]. The volume thus deduced corresponds to a state without hydrogen bonding (at 0° C. about 8 per cent denser than ordinary water). Each hydrogen bond formed at a given temperature ($t < 174°$ C.) is now assumed to affect the ideal liquid in the same way, raising the molecular volume to that of ice when two moles of hydrogen bonds are established. (Ice is supposed to exhibit the same thermal expansion above 0° C. as immediately below.)

Introducing the observed volume of water, these assumptions render possible the determination of the molecular fraction of hydrogen bonds, X, as a function of temperature. At 0° C., X is calculated to be 0·44, decreasing to 0·23 at 100° C. When no hydrogen bond is broken, the number being two per molecule, X is one.

Following Finbak[2], the law of mass action is applied to the formation of hydrogen bonds. The breaking of a bond gives two sites for bond formation. Thus a graph of $2\ln(1 - X) - \ln X$ against $1/T$ was investigated. An almost straight line was obtained, corresponding approximately to an enthalpy change of 2·6 k.cal./mole water and an entropy change of 8·9 cal./mole.

A hydrogen-bond energy of 1·3 k.cal./mole seems quite low, compared with the current estimates for water. There has been no general agreement, however, on the energy of the hydrogen bond. This is probably due to difficulties in defining and sharing out the different energies. The present investigation indicates that 2·6 k.cal./mole is responsible for the tendency towards tetrahedral configuration in water. This is ascribed to the hydrogen bond. The van der Waals's energy superimposed gives only a very loose orientation effect, though it is probably partly included in most hydrogen-bond energy determinations.

A detailed discussion will appear later elsewhere.

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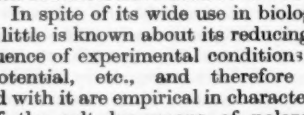
Reduction of Tetrazolium Salt

Some two hundred papers dealing with the chemistry of triphenyltetrazolium chloride and its use as a redox-indicator have been reviewed by Ried[1] and Smith[2]. In spite of its wide use in biology, up to the present little is known about its reducing mechanism, the influence of experimental conditions on it, on its redox-potential, etc., and therefore the results obtained with it are empirical in character. Investigations of the salt by means of polarography and spectrophotometry carried out in this laboratory revealed some aspects which should be considered when using it as a chemical indicator of reducing power in biological reactions.

Polarographic study has shown that, in media of *p*H lower than 6, the reduction of triphenyltetrazolium chloride yields chiefly a colourless product:



In more alkaline solutions the reduction product is mainly the red formazan. This behaviour is due to the change of redox-potentials in the reduction of nitrogen atoms 1 and 2, and atoms 2 and 3 respectively (Fig. 1), and explains why reddening can be achieved only in solutions which are not too acid. The redox-

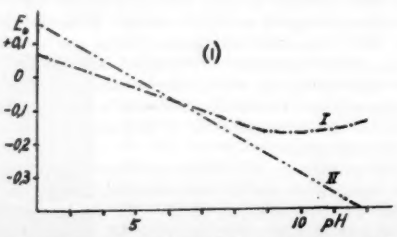


Fig. 1. Redox-potentials of triphenyltetrazolium chloride. Reduction of nitrogen atoms 2 and 3 (curve I) and of atoms 1 and 2 (curve II)

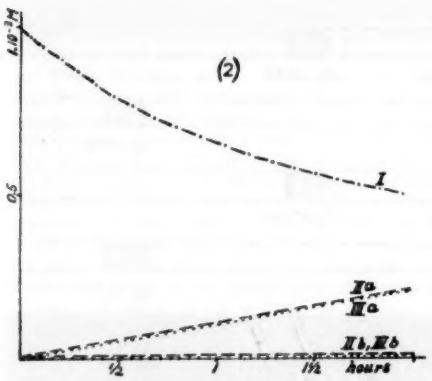


Fig. 2. Reaction-time curves of 10^{-3} *M* triphenyltetrazolium chloride
Curve I; disappearance of pure triphenyltetrazolium chloride in solution in light, neutral medium.
Curve II, *a*: formation of formazan, in the presence of 10^{-2} *M* ascorbic acid, *p*H 10·8, in light. Curve II, *b*: the same, in darkness.
Curve III, *a*: formation of formazan in a diluted suspension of yeast (0·1 gm. →10 ml.), *p*H 7·5, in light. Curve III, *b*: the same, in darkness

potential of formazan formation, contrary to other redox-indicators, cannot serve as a basis for predicting whether some reducing agent of known redox-potential will produce formazan or not. This is due to the insolubility of the reduced form of triphenyltetrazolium chloride: no redox-equilibrium can be established, and the actual potential of the substance will be therefore much more positive than its normal potential. This shows why triphenyltetrazolium chloride can be reduced by succino-dehydrogenase, which has a much more positive normal redox-potential.

Another important point to be considered is the influence of light on the enzymatic and non-enzymatic reduction of triphenyltetrazolium chloride. Fig. 2 shows that both types of reduction take place only in light; there is no reddening in darkness, except non-enzymatic reduction in strongly alkaline solution. Fig. 3 shows the influence of *p*H on both types of reduction, indicating clearly the basic difference between the two types of reactions. Fig. 2 shows also that triphenyltetrazolium chloride even in pure solution is converted by light into a 'photo-compound', which cannot be reduced to formazan. (The source of light in these experiments was the scattered light of the blue sky, of about 2,500 lux.)

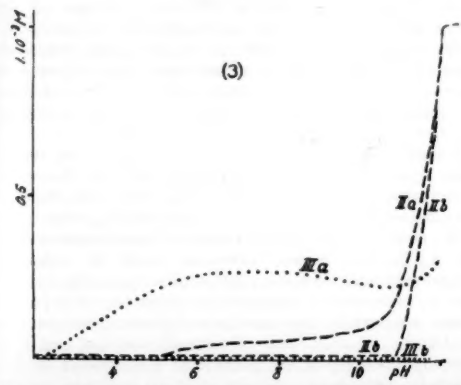


Fig. 3. Influence of *p*H on the formation of formazan in 10^{-3} *M* triphenyltetrazolium chloride, solution allowed to stand 2 hr. with ascorbic acid (yeast). Details as in Fig. 2

Formazan is decomposed photochemically, as shown by Kuhn and co-workers[3]. According to our experiments, this is an autocatalytic reaction, with the 'photo-compound' as catalyst. Hydrogen peroxide is formed as a by-product.

An interesting factor causing complications is further that triphenyltetrazolium chloride is converted into formazan in strongly alkaline medium spontaneously without the action of light or any reducing agent.

These results show clearly that the conditions must be carefully controlled when triphenyltetrazolium chloride is used for quantitative experiments.

Further details of this investigation will be published elsewhere[4]. I am indebted to Arapahoe Chemicals, Inc., Farbenfabriken Bayer and Lewis Laboratories, Inc., for supplying the triphenyltetrazolium chloride.

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Leucofuchsin in Algal Cytology

Astbury and Sana, in an article in *Nature*[1], state that there is some correspondence between the X-ray diagram of *Polytoma* flagella and that of certain polysaccharides; but no chemical confirmation of the presence of this type of compound could be found.

The diversity in structure of various algal flagella cautions against generalization. While the electron-micrograph given by Astbury and Sana represents *Euglena*, the X-ray diagram refers to *Polytoma*. These organisms are not closely related, if at all, and have different flagellar structures. In *Euglena*, the main stem of the flagella is covered with appendages which, in their dimensions and physical properties, recall bacterial flagella, although their function and behaviour are unknown.

In *Polytoma*, the delicate distal part of the flagella has approximately the same width as the appendages of the Eugleninean flagellum though it is stiffer, while the basal part is almost as thick as the flagellum of *Euglena*. There are still more differences in flagellar structure between the phylæ of flagellates, which have to be kept in mind when investigating the physical and chemical nature of algal flagella.

By accident I came across a reaction which might be of help in such studies. In an attempt to learn something about the composition of paramylon, the peculiar reserve substance of the Euglenineae, which is chemically and physically similar to starch, the leucofuchsin technique, as used for demonstrating polysaccharides in histology[2], was employed; in this method, after oxidation with periodic acid, the cells are treated with Schiff's reagent (leucofuchsin). The result is that, unlike starch, paramylon is not stained.

All the flagella tested, comprising those of *Euglena*, *Eutreptia*, *Phacus*, *Cyclidiopsis*, *Polytoma*, *Chlamydomonas*, *Gonium*, *Ochromonas* and *Cryptomonas*, gave a positive reaction and became red in every instance,

those of the first four most distinctly, probably because they belong to the Euglenineae, which have wider flagella than the rest. Pre-treatment with saliva and washing with fat-solvents made no difference.

This positive reaction supports the view that there is, apart from proteins, also a polysaccharide component in all these flagella. The polysaccharide may have something to do with the marked elasticity of algal flagella and their defined way of beating, characteristics which are lacking in bacterial flagella and in the appendages of the Eugleninean flagellum, to judge by their shapes in electron-micrographs. The flagella of bacteria do not contain polysaccharides, so far as we know. The cilia of *Paramecium caudatum*, which are much shorter than flagella, do not seem to need elastic stiffening and give no leucofuchsin reaction.

A positive Schiff's reaction, however, was obtained after oxidation with periodic acid in the chlorophyll-containing chromatophores of all the organisms tested: Volvocales, Cryptophyceae, Euglenineae, Peridineae and Chlorophyceae, while without previous periodic-acid treatment no staining took place.

Apart from the Feulgen reaction, Schiff's reagent has previously been used for staining cell-walls of Algae. Prát[3] found that those of Heterocontae became purple-red with this reagent, in contrast to the cell-walls of Chlorophyceae. I can confirm his result.

After treatment with periodic acid, a positive result with Schiff's reagent is given by cell-walls of Cyanophyceae, *Spirogyra* and some Volvocales. A few Chlorophyceae tested were negative.

It may be mentioned that the leucofuchsin solution should be nearly colourless, or only pale yellow, but must not show the faintest tinge of pink, as traces of the unreduced fuchsin have a strong staining power.

I thank Dr. H. B. Fell for laboratory accommodation and the New York Zoological Society for a grant.

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Identity of Auxin in Normal Urine

The aim of this work was to obtain auxin *a*, first isolated by Kögl, Haagen-Smit and Erxleben[1] from human urine in 1933. In their isolation procedure, these workers extracted a urine concentrate at an acid *p*H with ether. The ether extract in turn was partitioned into a neutral and an acid fraction with sodium bicarbonate. The auxin was present in the acid fraction and was subjected, in the final stages of the isolation procedure, to refluxing with methanol containing 1·5 per cent hydrochloric acid. This step was followed by high-vacuum distillation, yielding a crystalline material with high auxin activity which they called auxin *a*.

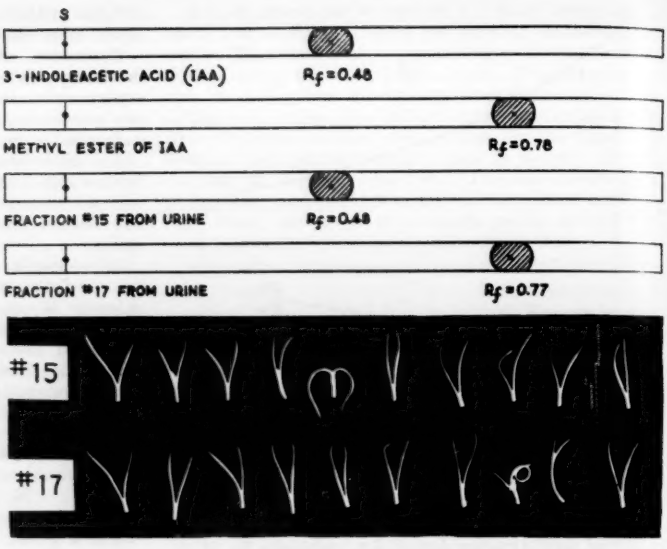

Fig. 1. Above: paper chromatograms of 3-indoleacetic acid and of its methyl ester compared with fractions 15 and 17 from urine. Below: biological activity of ten equal segments of the paper strips (R_F 0–0·1, 0·1–0·2, etc.) by the split *Avena* coleoptile test

In the present work, the procedure of Kögl *et al.* has been followed throughout. The auxin activity of the fractions was determined not by the *Avena* curvature test but by the split coleoptile test of Thimann and Schneider[2], which will detect 0·1 mgm./litre of 3-indoleacetic acid. Two batches of 40 litres of urine were processed and from them, after treatment with methanolic hydrochloric acid and high-vacuum distillation, a pale yellow oil was obtained having an activity about ten times that of indoleacetic acid as estimated by the split *Avena* coleoptile test.

The high-vacuum distillate (fraction 17) and its precursor before esterification with methanolic hydrochloric acid (fraction 15) were both studied by paper chromatography using the solvent system *iso*propyl alcohol – water – ammonia, 80–15–5. Some of the strips were sprayed with ferric chloride in perchloric acid[3], others were cut into ten equal segments, each segment being placed in a Petri dish with three split *Avena* coleoptiles. The location of the coloured spots on these strips and the distribution of biological activity is shown in Fig. 1.

Fraction 15 gave a pink spot identical in colour with that given by 3-indoleacetic acid of R_F value 0·48 (3-indoleacetic acid had R_F 0·48). Fraction 17 gave a purple spot (R_F 0·77) identical in colour with that given by the methyl ester of 3-indoleacetic acid (R_F 0·78), which was prepared both by refluxing 3-indoleacetic acid with methanolic hydrochloric acid and by treating a methanolic solution of 3-indoleacetic acid with diazomethane. From fraction 17 a crystalline picrate was obtained identical with an authentic sample of the picrate of the methyl ester of 3-indoleacetic acid.

As can be seen from Fig. 1, the auxin activity on the paper strips (shown by curvature of the split

halves of the *Avena* coleoptile) coincided exactly with the coloured spots. No other region on the strips had auxin activity and none of the other fractions was active. These findings are in agreement with those of Bennet-Clark *et al.*[3], who were unable to detect any auxin other than 3-indoleacetic acid in paper chromatograms of an ether extract of urine.

When the isolation procedure of Kögl *et al.* was applied to a solution of 3-indoleacetic acid, it resulted in the isolation of the methyl ester of this substance. There appears to be no step in this isolation scheme which would eliminate 3-indoleacetic acid or separate it from auxin *a*. In their paper on the isolation of 'hetero-auxin', Kögl *et al.*[4] state that it remains a "companion of auxin *a* for a long time" but that "the last traces of heteroauxin are destroyed by refluxing with methanol containing 1·5% HCl". In our work, however, no such destruction was observed, provided dry methanol and dry hydrogen chloride were employed.

These results lead to the following conclusions:

(1) Neither of the two 40-litre samples of urine processed contained any auxin except indoleacetic acid.

(2) Treatment of the active fraction with methanolic hydrochloric acid does not destroy the 'hetero-auxin' as suggested by Kögl *et al.*[4] but converts it to the methyl ester. The auxin activity of this ester as estimated by the split *Avena* coleoptile test and by the split pea internode test was greater than that of 3-indoleacetic acid. Kögl and Kostermann[5] found the methyl ester less active than the free acid when tested by the *Avena* curvature test.

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Blood-sugar in Fœtal and Neonatal Mammals

It is well known that glucose is not found in equal concentration in the water phase of the red cells and plasma from some species of adult mammals. Nevertheless, it is conventional and convenient to cite values for the glucose concentration in the whole blood, and in studies confined to man this practice is generally satisfactory. In comparative physiology there is less justification for this convention, because it is the plasma glucose concentration which has a more direct influence on the tissue-fluid glucose concentration and sugar-regulating mechanisms. The difference between whole-blood and plasma glucose concentration is frequently considerable, for when the red cell is seemingly devoid of glucose, the plasma glucose concentration is, on the average, about 1·5 times the blood glucose concentration.

The importance of estimating plasma glucose became obvious in this laboratory during a study of the glucose concentration gradient across the placenta of the guinea pig. The blood glucose concentration was sometimes virtually the same in the fœtal and maternal circulations but, on estimating plasma glucose, a considerable concentration gradient existed towards the fœtus as shown in the accompanying table.

Maternal circulation		Fœtal circulation	
Glucose mgm./100 ml.		Glucose mgm./100 ml.	
Blood	Plasma	Blood	Plasma
92	135	92	104
64	85	64	75
106	136	97	102
88	115	87	97
80	110	79	86
Mean 86	116	84	93

Previously, Hitchcock[1] had reported peculiarities in the corpuscular/plasma distribution of glucose in the young lamb. His findings suggested that this ratio declined rapidly after birth. In addition, Andreen-Svedberg[2] had observed a high distribution-ratio for glucose in blood from young calves and a baby pig.

In view of the implications above, this phenomenon has been examined in a large number of animals of several species (horse, pig, ox, sheep, goat, guinea pig and rabbit).

Fresh blood was collected over dried heparin at about 2° C. and, after sampling, the remaining blood was centrifuged in cups packed with ice until sufficient plasma was exposed. Generally, all deproteinization (using barium hydroxide and zinc sulphate) was complete within about twenty minutes of obtaining the blood. Glycolysis has been shown to be negligible during the whole procedure. Corpuscular glucose was derived from a knowledge of blood and plasma glucose and the packed cell volume. It is assumed that this technique, which examines the red cell in its natural medium, does in fact measure the *in vivo* concentration of glucose. The methods for estimating sugar have been described in a previous publication[3].

The following general observations have been made.

1. The distribution of glucose usually conforms to one of two conditions: (*a*) an approximately equal concentration of glucose in the water phase of the red cell and the plasma (assuming that the water contents are similar to those in man); (*b*) a low or zero concentration of glucose within the cell. These two states may represent the conditions of free permeability and impermeability; but, pending further investigations along these lines, they will be referred to here as 'state *a*' and 'state *b*'.

2. In most species examined, the fœtal and immediately post-natal corpuscles are in state *a* and, during the neonatal period, they change gradually to state *b*. It is possible that there are only two types of corpuscle and that the first is slowly replaced by the second.

3. The period of life during which this red-cell change occurs can vary with species: the corpuscles in the new-born pig being in state *a*, while those of the foal at birth are already in state *b*. As the change has always been observed to be from *a* to *b*, it is assumed that *a* is more immature and that a physiological change in the reverse direction would never occur. The persistence of the *a* corpuscle throughout life in man may be a reflexion of the mode of evolution of this species.

4. The consistently higher concentration of glucose within the cell compared with that in the plasma, as described by Hitchcock for the fœtal lamb, has not been seen in this work for any species at any age.

5. A further complication may result in animals where more than one sugar is present in the blood[3], for preliminary results suggest that the corpuscular/plasma sugar distribution may be different for glucose and fructose.

From these results, it is clear that, in fœtal and neonatal physiology, the term 'blood-sugar' should be used only in a strictly literal sense. Figures derived from blood-sugar estimations cannot be legitimately compared, either for different species or for different ages of one species, without allowing for the particular characteristics of the red cell in each sample.

I am indebted to Dr. R. Scarisbrick, who not only directed my attention to this problem, but suggested that it should be developed in this way.

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Resistance to the Maize Rust, *Puccinia polysora*

During 1953 we have studied resistance in maize to the form of the rust fungus, *Puccinia polysora* Underw., that recently appeared in East Africa[1]. Our results augment the information given by Stanton and Cammack[2].

In our glasshouses at Muguga, Kenya, inoculation of young maize seedlings with fresh uredospores regularly caused infection, once technique was perfected. In a susceptible maize, uredosori were strongly developed about fourteen days after inoculation (Fig. 1). There was some variation between plants in the size and frequency of the sori and in the extent of the chlorosis surrounding them. Some plants, however, gave a distinct reaction, readily distinguished from any variant of the preceding reaction, the inoculated leaves showing only discrete, nearly circular necrotic areas, in which no sori developed or minute sori with limited spore-production (Fig. 2). This resistant reaction resembles the hypersensitive reaction well known with the rusts of wheat; it conforms with the description of Stanton and Cammack's "Stage 1"[2]. A few plants, selected as seedlings, were grown to maturity in a glasshouse and reinoculated at intervals; their reaction at later stages of growth resembled that shown by them as seedlings.

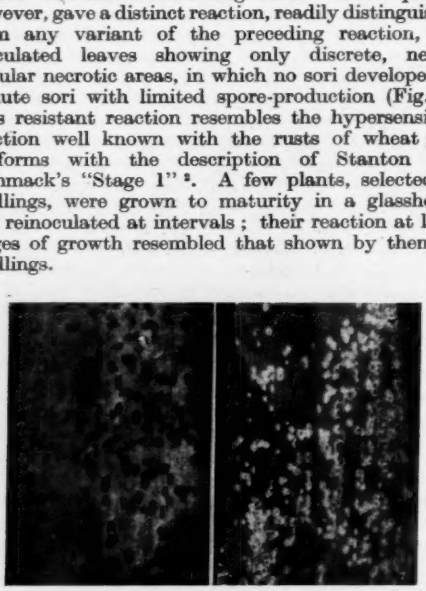

Fig. 1. *Puccinia polysora*. Susceptible reaction in maize leaf. Large spreading sori. (× 1·75)

Fig. 2. *Puccinia polysora*. Resistant reaction in maize leaf. Necrotic areas with some small sori. (× 1·75)

Table 1. Selfed Progenies

Parent			Progeny tests	
Country of origin	Line No.	Family No.	Plants resistant	Plants susceptible
Mexico	24	(1)	9	5
		(2)	0	4
	27	(1)	13	7
		(2)	9	5
Colombia	28	(1)	23	5
	29	(1)	16	3
	30	(1)	6	2
		(2)	20	4
	31	(1)	7	7
		(2)	7	3
	32	(1)	6	3
Totals			125	48
Expectation on 3 : 1 ratio			130	43

None of our material has given evidence of immunity from invasion by the fungus.

The resistant reaction was not found in any of forty-two maize varieties and lines received from sources in Africa. It was found in a few plants among collections originating in Mexico (received through Dr. W. Stanton) and in Colombia (Dr. L. M. Roberts, Agricultural Experiment Station, Medellin). Of twenty-five varieties and lines from these sources, fifteen gave only the susceptible reaction and the resistant plants were confined to the remaining ten.

Individual plants showing the resistant reaction were grown to maturity and selfed or crossed with susceptibles. Twelve progenies raised from selfed seed were tested. Of these, one gave forty-five plants all resistant in seven separate tests. The remaining eleven segregated into resistants and susceptibles as shown in Table 1.

Thirteen resistant plants were crossed with susceptibles; one gave twenty-eight plants all resistant (four tests) and the remainder segregated (Table 2).

The evidence indicates the presence of one major dominant gene for resistance. Differences in the responses that have been classed together as indicating susceptibility in the above progenies, and also in some progenies of North American origin, suggest the presence of at least one other gene with an effect

Table 2. Crossed Progenies

Resistant parent			Progeny tests	
Country of origin	Line No.	Family No.	Plants resistant	Plants susceptible
Mexico	24	(1)	6	8
	27	(1)	13	15
		(2)	3	5
Colombia	28	(1)	11	10
	29	(1)	5	9
		(2)	8	4
		(3)	4	10
		(4)	10	4
	30	(1)	10	4
		(2)	7	13
		(3)	7	6
	31	(1)	9	17
Totals			93	105
Expectation on 1 : 1 ratio			99	99

large enough to be of possible value in breeding for resistance. We are continuing our studies of this possibility; meanwhile, our work is mainly concentrated on establishing maize stocks homozygous for the major gene in the expectation that these will be of use to those breeding for *P. polysora* resistance.

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Seedling Resistance and Mature-Plant Susceptibility of Wheat to *Puccinia graminis* found in Kenya

Breeding and selection of wheat in Kenya for resistance to black stem rust has been based on seedling resistance tests coupled with identity tests of rust forms from the field and the breeding cages. Owing to lack of facilities, mature-plant tests have not been undertaken.

Though seedling and mature-plant resistance has been demonstrated to be independent[1], it has been found in Kenya that, by selecting resistant seedling lines, mature-plant resistance until recently has always been obtained. Such was the success of the plant breeders that the value of Kenya wheats has been recognized in various parts of the world, and they have been used as parents in breeding programmes, for example, in Australia, India, Egypt, the United States and Canada. Several seedling-susceptible but mature-plant resistant lines may well have been discarded in this process, for it is known that some varieties develop a mature-plant resistance from about the fifth leaf stage[2]. This character was used by E. S. McFadden when he produced Hope and *H.*44.24 by crossing Yaroslav Emmer and Marquis[3].

This seedling resistance – mature-plant resistance has, however, not held throughout. Seedling resistance – mature-plant susceptibility has been found in the following Kenya lines: 184 and 318 and in *D.C.* × Ceres *R.*46. These wheats were seedling resistant to certain rust forms by which they were attacked in the field. Their seedling resistance to other rust forms has apparently been maintained. All selections of these lines do not exhibit this behaviour, but remain constant in their resistance or susceptibility.

It has recently been shown in the United States[3] that lines involving Mentana and some other parents behave in a like manner.

I wish to thank the Honorable Director of Agriculture, Kenya Colony, for permission to publish this preliminary communication.

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Parsnip Canker: Selection of Resistant Stocks of Parsnip

The account by A. P. Jones[1] in *Nature* on *Streptomyces scabies* (Thaxter) Waksman and Henrici as the probable cause of parsnip canker is a welcome addition to the literature on a problem which has defied solution by various investigators during the past forty years. Previous to the above work, a survey of the problem was made by us during the period 1946–49 at the request of the Horticultural Group of the Agricultural Improvement Council and the results were embodied in the report AIC/HG/20, a summary of which was published in *Agriculture*[2]. That report claimed to be no more than a fresh examination of the problem; but, although the exact nature of the causal organism was not discovered, a good deal of information was obtained. During the investigation it was clear that although no commercial variety or strain of parsnip was worthy of being called resistant to canker, there were always individual roots which in badly affected fields remained free from the trouble. This point has been noted by previous workers[3].

Consequently, while the examination was proceeding, a look-out was kept for roots which remained clean in areas where canker was abundant. Such roots were intended to form a foundation for the selection and breeding of canker-resistant stocks possessing characters suitable for commercial crop production such as those possessed, for example, by the variety called Evesham. This variety is yellow-fleshed, broad in the shoulder and short in the root (that is, peg-top in shape) and is much valued on heavy soils because it lifts easily where longer varieties break off. It is, however, rather prone to canker.

The first roots were selected at the end of the very bad canker year of 1948, after which, in the spring of 1949, it was difficult to find parsnip roots free from canker. With the assistance of National Agricultural Advisory Service advisers in different parts of the country specimens were gathered and forwarded to Wisley, and from them ten clean roots of suitable types were chosen. These were planted at Wisley for seed production. Seven survived and were seeded under large muslin bags, and the seed was sown in February 1950 in heavy land where canker usually occurs. As the main investigation had shown that canker infection increases after October in any year, it was decided to leave the roots until late spring before lifting for examination.

The seven stocks sown in February 1950 were lifted in March 1951. In no case was canker severe, and two stocks (Nos. 4 and 5) were completely clean and of a good type. From them seven good roots were selected and replanted, protected with muslin, and seed harvested from each in the autumn. This was sown on the same land in February 1952 and the crop was lifted on March 10, 1953, when canker infection in six of the stocks varied from 0 to 11 per cent. The seventh stock, of which the seed had been badly discoloured, gave 34 per cent cankered roots. These roots were very large, their average weight being 50 per cent more than that of roots in the next heaviest stock, and this point may have some connexion with their susceptibility to canker. The fact remains that, in this trial as in previous ones, although canker was present in some stocks, there were others free or practically free from the trouble. The work to date indicates that resistance to canker

exists in certain stocks from which it may be possible to select or breed varieties combining the resistance with acceptable commercial characters.

During the latter part of the work we have been in touch with the staff of the National Vegetable Research Station, and we are indebted to them for much interest in the parsnip trials. As part of their work will deal with parsnip canker, it was decided to offer them any material in which they were interested and this offer was accepted. Accordingly, at the lifting in March 1953 roots from each of our seven stocks of parsnips were sent to Wellesbourne for seeding there and in the hope that they will be of some value in any further research on canker. This communication is written to explain the origin and history of the stocks from the spring of 1949 onwards.

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Factors influencing the Emergence of *Heterodera rostochiensis* Larvæ

Many investigators have reported a considerable variation in the seasonal rate of hatching of eggs from the cysts of *Heterodera rostochiensis*, in the presence of root diffusate.

Both Fenwick[1] and Lownsbery[2] have shown that the direct effect of temperature on cysts *in vitro*, in the presence of root diffusate, caused an increase in the amount of hatching with rise in temperature. They found the optimum rate of hatch was between 21° and 25° C., and both reported inhibition of hatching or dormancy at temperatures of 30°–33° C.

Recent investigations in this laboratory indicate, however, that seasonal variations in hatching are not simply the result of a direct correlation between temperature and hatching. It has been shown that the rate and amount of hatching from viable cysts of the same age maintained at 15° C. is profoundly influenced by the maximum temperatures to which the moist cysts have been subjected previously, before the addition of root diffusate. Except for a very brief note in a paper by Calam, Raistrick and Todd[3], there appears to be no record of this indirect effect of temperature on moist cysts.

Samples of cysts of the same age were kept in water at temperatures of 15°, 23° and 29° C. for 34 days, and afterwards at 15° C. Two days later root diffusate was added to all samples. Four days afterwards, the cysts which had been pre-heated at 23° C. produced a hatch twenty to thirty times as great as the hatch from the cysts kept at 15° C., while none hatched from the cysts pre-heated at 29° C. All attempts to hatch eelworms from samples of cysts which had been kept at 29° C., by the addition of root diffusate, failed until twenty days after removing to the lower temperature of 15° C. The hatch was then very rapid and somewhat similar to that from cysts pre-heated at 23° C. Small amounts of hatching also occurred after the twentieth day in control batches of cysts pre-heated at 29° C. and to which no root diffusate had been added, in numbers similar to the emergence from cysts kept at 15° C.

These hatching results may explain the unexpected tomato and potato crop failures which occasionally occur at moderate viable cyst population levels, and would seem to explain the absence of winter dormancy reported by Fenwick[4] and the winter dormancy noted by Lownsbery[2] in the United States, where according to him the mean soil temperature of 6 in. depth averaged 22° C. during the summer.

This work is being continued and these results will be reported more fully elsewhere.

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Effect of Oxygen on the Fixation of Nitrogen by *Azotobacter*

Recent studies on the fixation of molecular nitrogen by both anaerobic[1] and aerobic[2] heterotrophic nitrogen-fixing bacteria indicate that ammonia is the first stable compound formed. This raises the question whether the necessary hydrogen is derived from water or from the metabolite. The latter source seems the more likely, especially since the union of metabolic hydrogen and molecular nitrogen to form ammonia could yield a considerable amount of free energy. If this were so, members of the anaerobic genus *Clostridium* would be expected to fix nitrogen more efficiently than the aerobe *Azotobacter*, which passes its metabolic hydrogen to oxygen. Results obtained in this laboratory show that *Clostridium* is, in fact, capable of more efficient nitrogen fixation than *Azotobacter*[3]. Again, if metabolic hydrogen is involved in the reduction of molecular nitrogen then, with a nitrogen-fixing aerobe, oxygen must compete with nitrogen for this hydrogen and so depress fixation. Conflicting results have been reported for the effect of partial pressure of oxygen on nitrogen fixation by *Azotobacter*[4].

The effect of oxygen upon nitrogen fixation was examined in this laboratory using one strain of *Azotobacter vinelandii* and one of *Azotobacter chroococcum*. Both were slow-growing strains, and were grown in shallow liquid layers to allow ready diffusion of gases into and out of solution. The medium was a 1 per cent sucrose salts solution at *p*H 7, and contained yeast extract. 10-ml. aliquots were poured into 10-cm. Petri dishes, inoculated and incubated at 28° C. in sealed jars with different partial pressures of oxygen. The atmospheres in the jars were renewed frequently until the cultures were harvested after 21 days. Inoculated controls were acidified, stored and analysed with the cultures by micro-Kjeldahl method. At 4 per cent oxygen, *A. vinelandii* fixed 23·5 mgm. nitrogen, and *A. chroococcum* 21·6 mgm. nitrogen, per gm. sucrose supplied; at 20 per cent oxygen the fixation was 8·1 mgm. and 7·4 mgm. nitrogen respectively. These results showed greatly increased nitrogen-fixing efficiency with decreased partial pressures of oxygen (significant at the 0·1 per cent level).

When considered with the reported inhibition of nitrogen fixation by molecular hydrogen[5], the inhibition by oxygen suggests that it is dehydrogenase hydrogen which is passed to nitrogen. Thus nitrogen

fixation might well be a form of respiration with nitrogen acting as an alternative to oxygen as a terminal hydrogen acceptor.

The bacteriological and agronomic implications of this theory will be discussed elsewhere, and further observations presented.

My thanks are due to the Rural Credits Development Fund of the Commonwealth Bank of Australia for financial assistance, and to Dr. R. J. Swaby, of the Division of Soils, Commonwealth Scientific and Industrial Research Organization, Waite Institute, Adelaide, for the culture of *Azotobacter vinelandii*.

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Dec. 1.

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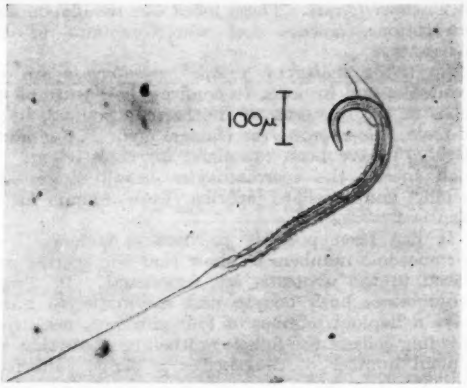
Second Ecdysis of Infective Nematode Larvæ Parasitic in the Horse

THIRD-STAGE infective nematode larvæ retain the sheath of the previous stage and, upon ingestion by the host, this is shed to liberate the enclosed individual. Lapage[1] showed that 'Milton' could induce an artificial ecdysis in the third-stage infective nematode larvæ of sheep. Glaser and Stoll[2,3] have reported successful results using a similar 'Labarraque' solution. Lapage[4] induced ecdysis in a mixture of hydrochloric acid and sodium hydroxide at *p*H 9–10 and, apart from the time taken (8–10 days), the process seemed normal. Crofton[5] studied the second ecdysis of *Trichostrongylus retortaeformis* (Zeder) and found that it could be initiated by pepsin and hydrochloric acid at *p*H 4–5, 60 hr. being required for exsheathment to occur. Stoll[6] investigated the ecdysis of the first parasitic stage of *Haemonchus contortus* (Rudolphi) and reported that it occurred in hypotonic Ringer or Tyrode solutions, the addition of aqueous liver extract being highly beneficial.

Experiments conducted here with hydrochloric acid and sodium hydroxide both alone and in combination to give *p*H 8·5 have repeatedly failed to induce ecdysis in the third-stage infective larvæ of the following equine nematodes: *Strongylus vulgaris* (Looss), *S. edentatus* (Looss), *Triodontophorus* spp., *Trichonema* spp., *Oesophagodontus robustus* (Giles) and *Trichostrongylus axei* (Cobbold). A temperature of 38° C. was maintained in all the experiments.

Successful ecdysis of the above species has, however, been repeatedly induced by utilizing muslin-filtered duodenal contents from freshly killed horses. The quickest time yet recorded for 100 per cent ecdysis is 1½ hr. in duodenal contents diluted with an equal volume of distilled water—the whole being kept at 38° C. Experiments with varying dilutions of duodenal contents have shown that the rate of ecdysis is directly proportional to the concentration.

Two distinct methods of ecdysis have been seen. The first is by detachment of a cap at the anterior end of the sheath as reported by Lapage[4] for *Haemonchus contortus*, *Ostertagia circumcincta* (Stadelmann) and *Trichostrongylus* spp. after 8–10 days, and by Crofton[5] for *Trichostrongylus retortaeformis* after



Third-stage larva of *Trichonema* sp. undergoing ecdysis by means of a split in the œsophageal region. (Photo. by O. Hughes)

60 hr. A similar process occurred in *Strongylus vulgaris*, *S. edentatus* and *Trichostrongylus axei* and was seen in some cases 60 min. after the addition of duodenal contents. The second method, which was observed in *Trichonema* spp., *Triodontophorus* spp. and *Oesophagodontus robustus* to occur equally quickly, does not involve the shedding of a cap. Larvæ of these species develop a bulge at the anterior end in the region of the œsophagus, lashing movements enlarge this and eventually it ruptures to produce a split through which the larva escapes. The accompanying figure shows a *Trichonema* sp. larva leaving its sheath by this means.

Further investigations now nearing completion show that normal ecdysis may be induced by boiled duodenal contents, pig or horse bile and sodium taurocholate. No ecdysis occurred in sodium glycocholate or taurine. The complete results of these experiments will be published in the near future.

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Reproduction in Notostraca (Crustacea)

IN some species of Notostraca, populations occur in which no males are found and these have generally been considered to reproduce by parthenogenesis; the European *Triops* (=*Apus*) *cancriformis* (Bosc.) exhibits a geographical variation in the occurrence of males, which are less common, or absent, in the north of its range, so that the species has been supposed to show parthenogenesis in colder, bisexuality in warmer regions, in the same manner as *Trichoniscus* (Isopoda, Crustacea)[1].

The account in the year 1889 by Bernard[2] of the discovery of testis lobes in the gonads of female *Triops cancriformis* has been overlooked by recent writers; but during systematic work, in which this genus is being investigated cytologically, I have found testis lobes in the gonads of all the specimens which were examined from so-called parthenogenetic races

of *T. cancriformis*. These lobes can readily be seen in sections, smears and whole mounts of the ovotestes.

No living males of *Triops cancriformis* are yet available, and in order to confirm the nature of the lobes in the ovotestis of the hermaphrodites, testes of male *Triops granarius* (Lucas) (syn. *T. numidicus* (Grube)) have been examined for comparison. In each species the spermatocytes in all stages and round, non-flagellate sperms were found to be identical.

It has been possible to obtain evidence from chromosome numbers to show that the sperms produced in the ovotestis are functional. In *Triops cancriformis* both oocyte and spermatocyte nuclei have a haploid number of four chromosomes, while dividing cells of the follicle epithelium show that the diploid number of the species is eight. Precisely similar chromosome numbers occur in the same cells of bisexual *T. granarius*, in which cross-fertilization takes place. The hermaphrodites appear to be self-fertilizing, for pairing does not occur and sperms are present in the oviducts and follicle ducts throughout adult life.

Hermaphrodites are able to lay viable eggs in the absence of males, a fact long known for the so-called parthenogenetic races of *Triops cancriformis*, and it has now been possible to confirm this with *Triops longicaudatus* (Le Conte) from a Californian rice-field population consisting entirely of 'females', which lay viable eggs into their brood-pouches in the absence of males. Their gonads proved to be ovotestes, similar to those of *T. cancriformis*.

In other species bisexuality appears to be invariable, for in examining many samples of *Triops granarius* from Africa and Asia, I have found no instance where a large number of females without males might indicate hermaphroditism. The ovaries of this species were found to contain no testis lobes, a fact correlated with the inability of the females to lay eggs in isolation, and confirmed abundantly with cultures from two South African localities. A single female of *Triops australiensis* (S. and H.) reared in isolation laid no eggs, thus fitting in with the account of Spencer[3], who examined ovaries of this species shortly after Bernard's report and found no testis lobes.

The populations of *Triops cancriformis* present an interesting problem; in some parts of the range the species is hermaphrodite, in others males occur sporadically, while bisexuality appears to be normal in North Africa. Brauer[4] showed that females from a central European population with sporadic occurrence of males were able to produce viable eggs in isolation, but they copulated normally when reared with males. I have not been able to obtain females from such a population to find out what mechanism enables them to produce viable eggs without mating. A female from a bisexual population from Algeria had no testis lobes in the ovaries, and it appears likely that the normally bisexual *T. cancriformis* reproduces in the same manner as *T. granarius*.

Bernard[2,5] also described an ovotestis in *Lepidurus arcticus* (Pallas) and in *Lepidurus apus* (L.). Specimens which I have examined of the former species from Alaska have, as he described, testis lobes crowded at the posterior end of the gonad, but no further investigation of this genus has yet been possible.

Hermaphroditism appears to be rare in Crustacea[6], having previously been known only in the Cirripedia, although in some Decapoda and some parasitic Isopoda a sex-change occurs during life.

Systematic and cytological work is being continued on *Triops* and will be described fully elsewhere when it is completed.

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Iron Excretion by *Daphnia* during Hæmoglobin Loss

Daphnia contains hæmoglobin in solution in the blood. The concentration of the hæmoglobin is variable and depends upon the quantity of oxygen dissolved in the outside water: the less oxygen, the redder is the blood[1]. I have made a histological study of the distribution of iron in the tissues of *Daphnia magna* Straus when gaining or losing hæmoglobin in response to a changed oxygen content of the water, and have found that when hæmoglobin is being lost from the blood, inorganic iron accumulates in the excretory organs.

The paired maxillary glands, or shell glands, of *Daphnia* are the excretory organs. Each consists of a closed internal cœlomic end-sac, the saccule, a long winding tube, the labyrinth, and a terminal loop, the vesicle, opening to the exterior[2]. These shell glands lie in the hæmocœle and so are bathed by circulating blood. The presence of inorganic iron was shown by Bunting's modification[3] of the Prussian blue histochemical technique. This does not reveal the iron in hæmoglobin.

Iron was found in the shell glands only at the time when the hæmoglobin concentration in the blood was decreasing, which suggests that the iron is derived from the breakdown of hæmoglobin and that it is being excreted. The distribution of iron within the shell gland supports this view, for iron was found both in the walls and in the lumen of the middle section or labyrinth, but only in the lumen of the distal section or vesicle. No iron was found in the inner portion or saccule. In the labyrinth walls the iron stains as blue granules, but in the lumen it stains as a diffuse blue coloration. It is thus apparent that iron is excreted from the walls into the lumen of the labyrinth and thence passes through the vesicle lumen out of the body.

At the same time as iron appears in the shell glands of *Daphnia* which is losing hæmoglobin, it is found in the walls of the paired anterior gut cæca and in the cells of the fat body. One cannot be certain that the iron in the gut cæca is being excreted, since, unlike the shell glands, the cæca also have iron when the blood is gaining hæmoglobin. But more iron is present in the cæca of animals when losing hæmoglobin than at other times, which points to excretion. In the fat body, too, there is most iron when *Daphnia* is losing hæmoglobin, and this suggests that here is a site of hæmoglobin breakdown, with the liberation of iron to be excreted by the shell glands and perhaps by the gut cæca.

The expulsion from the body of iron derived from hæmoglobin breakdown is in direct contrast to the state of affairs in mammals, where the iron from the

continuous destruction of red blood cells is conserved and used again for further hæmoglobin synthesis. In some mammals the iron derived from hæmoglobin breakdown is temporarily stored as ferritin[4], an iron-protein complex found in liver, spleen and bone marrow. I have been unable to obtain crystals of ferritin from *Daphnia* with the aid of cadmium sulphate, but it must be remembered that no ferritin has been found in oxen, sheep or deer.

Another striking difference between *Daphnia* and vertebrate animals is that in the latter, which continuously break down the hæmoglobin of old red blood corpuscles, the hæm portion of hæmoglobin, after losing its iron, is excreted as bile pigment, whereas in *Daphnia* no bile pigment has been detected, either in extracts of large numbers of individuals[5] or histologically. For the latter purpose I have used the method of Stein[6]. Since not only has no bile pigment been found in *Daphnia* losing hæmoglobin, but also no porphyrin either[5], it appears that the hæm is broken down beyond the bile pigment or porphyrin stage to simpler colourless compounds.

The work reported here will be described in full elsewhere.

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'Mixed Layer' Minerals from the Ordovician Bentonite Beds at Kinnekulle, Sweden

In the course of an investigation of the bentonite beds in the Ordovician strata at Kinnekulle, Sweden, it became evident that the main part of these beds was composed of clay minerals belonging to the type of 'mixed layer' minerals that have random interstratification of illite and montmorillonite layers. The bentonite beds have been described in a paper by Waern *et al.*[1] by Thorslund, who also collected the materials used in this investigation partly from the two upper thin beds with a thickness of about 1 ft. each, and partly from the lower bentonite bed, which has a thickness of as much as 6 ft.

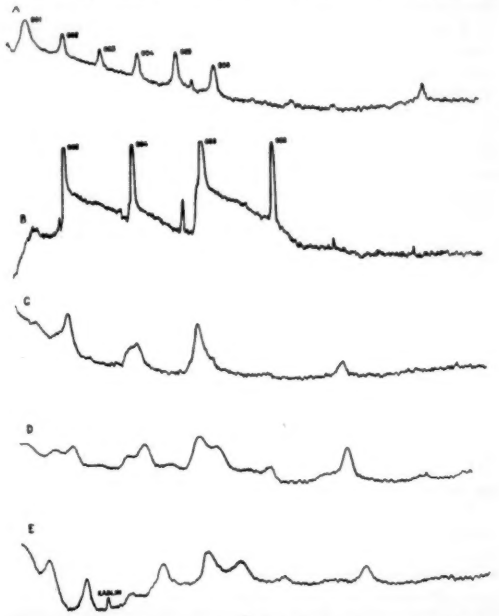
From chemical analyses, X-ray data, determinations of cation exchange capacities as well as from differential thermal analyses, and also from studies with the electron microscope, two different types of 'mixed layer' minerals have been distinguished. For one type, which is found mainly in the upper thin beds, the relation between illite and montmorillonite was found to be about 3 : 2. The K_2O content here was about 5 per cent. The other type constitutes the main part of the thick bed and has a much lower relation of illite to montmorillonite (about 1 : 4). The K_2O content in this case was about 2·5 per cent.

In Table 1 some data are collected for the two different types of 'mixed layer' minerals, and in the accompanying figure are microphotometer curves of some X-ray photographs of preparations, with layers oriented parallel to the basal planes. In this figure curves *A*, *B* and *C* are from pure minerals given here as a comparison, and curves *D* and *E* are from the material found at Kinnekulle. Actually, in curve *D* the double peaks are not so well resolved as could be expected from the photographic film, where the reflexions appear as two separate lines, although somewhat broad. From the curves we can see that the basal reflexions of the 'mixed layer' minerals are shifted in relation to those of montmorillonite and of illite, and that they can no longer be given rational indices that refer to cells of moderate size. This will also be seen from Table 2, where are listed intensities and spacings obtained from those preparations which gave curves *D* and *E* in the figure. The diagrams for random interstratification of layer minerals, given by Brown and MacEwan[2], have been used here to compute the ratio of illite layers to montmorillonite layers, and the values found from their curves are in agreement with those found in this investigation by other methods.

Table 1

	Type I illite/montm. 1 : 4	Type II illite/montm. 3 : 2
K_2O content	2·5 per cent	5 per cent
Cation exchange capacity	65 m.eqv./100 gm.	45 m.eqv./100 gm.
Low-order basal reflexions of non-oriented preparations	*st* 13–14 kX.	*m* 11·5 kX.
	with glycerol *vst* 17·8 kX., *st* 9·3 kX.	*m* 13·9 kX., *st* 9·6 kX.
Endothermal reaction temp. from D.T.A.	570°–590° C. 880° C.	600°–625° C. 900°–920° C.
Dehydration temp.	120°–180° C. 425°–500° C.	120°–180° C. 450°–550° C.

The material was very difficult to disperse in the media commonly used, and even after repeated



Microphotometer curves of X-ray reflexions from glycerol-treated specimens, oriented parallel to the basal planes. *A*, sodium-montmorillonite; *B*, thin sheet of muscovite; *C*, illite, Tosterup, Sweden; *D*, mixed layer mineral from Ordovician bentonites, Kinnekulle, Sweden, type II; *E*, mixed layer mineral from Ordovician bentonites, Kinnekulle, Sweden, type I

Table 2. Intensities and Spacings from Basal Reflexions of Oriented, Glycerol-treated Specimens of Bentonite Material from Kinnekulle, Sweden

Type I		Type II	
I	d_{001} kX.	I	d_{001} kX.
vst	18·0	st	13·1
st	9·0	vst	9·6
w	5·71	m	5·46
st	4·44	st	4·74
vst	3·42	vst	3·44
st	2·93	st	3·10
w	2·55	m	2·45
st	1·92	w	2·12
		st	2·04
(w	7·07)		

dispersions the sedimentary analyses showed all fractions to contain aggregates of the same type of clay minerals as found in the finest fractions. The material from the thick bed always showed a slight content of kaolinite (see figure, curve *E*), which was never found in the thin beds. The quartz content was very high in the thick bed and the fraction with particle size less than 2 μ also contained some quartz. This mineral was also found in the thin beds, but in a much smaller amount.

The fact that only two distinct types of interstratification of montmorillonite and illite are found in the very abundant material from the bentonite beds at Kinnekulle, and not a complete series of transitions between the end-members, makes it appear probable that certain proportions are more stable than others. No doubt there are variations around the value of highest stability as the reflexions from the bentonite material are always broadened and somewhat diffused, as can be seen from the photometer curves. The proportion of highest stability seems to be connected with a repetition of five layers. In the material from Kinnekulle the ratios 1 : 4 and 3 : 2 were found, and earlier a mixed layer mineral of the same type was described by Weaver and Bates[2], who found the ratio of illite layers to montmorillonite layers to be 4 : 1.

The material from Kinnekulle has also been compared with bravaisite, which was found by Bradley[4] to consist of layers of montmorillonite and illite in random interstratification, and type II with the illite/montmorillonite ratio of 3 : 2 seems to be very nearly related to this mineral.

The following structure formulæ are characteristic of each type:

Type I

$$(Si_{7\cdot36}Al_{0\cdot44})\ (Al_{3\cdot32}Fe^{3+}_{0\cdot28}\ Fe^{2+}_{0\cdot07}\ \overset{\uparrow}{Mg}_{0\cdot76})\ K_{0\cdot43}O_{20}\ (OH)_4 \qquad M^+_{0\cdot61}$$

Type II

$$(Si_{7\cdot36}Al_{0\cdot64})\ (Al_{3\cdot12}Fe^{3+}_{0\cdot17}\ Fe^{2+}_{0\cdot05}\ \overset{\uparrow}{Mg}_{0\cdot66})\ K_{0\cdot36}O_{20}\ (OH)_4 \qquad M^+_{0\cdot40}$$

M^+ denotes an exchangeable ion and is chiefly calcium or magnesium in the relation 4 : 1.

A more detailed report will be published in Sv. Geol. Unders. Årsbok, Ser. C.

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Failure to Publish Scientific Results

Prof. P. A. Buxton's letter in *Nature* of February 27, p. 410, complaining that the results of the aerial spraying experiments carried out in East Africa have not been made available is misleading and unfair to the workers concerned. Such experiments take nearly three years to complete because, although the air spraying may only occupy a matter of a few weeks, the assessment of the tsetse fly population before treatment, and more particularly after treatment, occupies a considerable time. Nine scientific papers have, however, been written up which deal fully with the work which has been carried out over the past six years. Four of these have already been published in addition to a communication in *Nature*[1–5], and the remaining five will appear during the present year.

In addition to the papers referred to above, members of the Colonial Insecticides Research Units have published ten scientific papers on other aspects of insecticide work during the past six years, and further papers are following. It is therefore a little unkind of Prof. Buxton to imply that these officers have omitted to write proper papers and have contented themselves with 'roneo-ed' progress reports. He appears to forget that the primary purpose of spending public money on Colonial research is a practical one, and that unless staff is unlimited the time occupied in the meticulous preparation required for a paper published in a scientific journal means delay in pressing on with the exploitation of preliminary results which can usefully be communicated to all the people most concerned with them by interim cyclostyled reports.

These interim reports have a wide circulation in the 'open' section of *Insecticide Abstracts*. There can be few people actively engaged in research on aerial insecticide treatment of insects who are not fully in touch with the progress of the work being carried out by the Colonial Insecticides Research Units, and none need be so ignorant of it that they are driven to use "other people's work". Although one endeavours to give the fullest references when writing up original work, it is not impossible, when one knows of the existence of work, to refer to it as 'in the press' or 'private communication', whichever is appropriate.

It would be difficult to give accurate figures for the cost of the air-spraying experiments, but it is common knowledge that the work with aircraft is costly. That it has been worth while is shown from the recent work[6] at Maruzi, Uganda, where, in a sixteen square mile area of bush, a kill of more than 99·95 per cent of tsetse fly has been achieved by spraying from aircraft at a cost of approximately £1,000 per square mile.

W. J. Hall
(Chairman,
Colonial Insecticides Committee)

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Cromwell Road,
London, S.W.7.

[1] Hocking and Yeo, *Bull. Ent. Res.*, **44**, 589 (1953).
[2] Hocking, Parr, Yeo and Robins, *Bull. Ent. Res.*, **44**, 601 (1953).
[3] Thompson, *Bull. Ent. Res.*, **44**, 611 (1953).
[4] Hocking, Parr, Yeo and Anstey, *Bull. Ent. Res.*, **44**, 627 (1953).
[5] *Nature*, **172** 168 (1953).
[6] Private communication.

FORTHCOMING EVENTS

(Meetings marked with an asterisk • are open to the public)

Monday, April 26

ROYAL SOCIETY OF EDINBURGH (at 24 George Street, Edinburgh), at 4.30 p.m.—Lectures under the Terms of the Robert Cormack Bequest. Mr. A. E. Roy: "The Occurrence of Commensurabilities in the Mean Motions of Planets and Satellites"; Dr. M. J. Smyth: "Photoelectric Investigations of Solar Corpuscular Radiation"; Dr. J. Cisar, Mr. James Ring and Dr. W. L. Wilcock: "Dielectric Interference Filters and their Recent Applications in Astronomical Photography"; Mr. M. W. Ovenden: "Photometric Effects of Gaseous Envelopes in Eclipsing Binaries".

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. W. S. Stiles: "Problems of Colour Vision".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. W. Lawrence: Informal Lecture on "The Experimental Synthesis of Speech".

INSTITUTE OF METALS (at the Royal Institution, Albemarle Street, London, W.1), at 7 p.m.—Prof. L. F. Bates, F.R.S.: "The Domain Structure of Ferromagnetic Metals" (Annual May Lecture).

Monday, April 26—Saturday, May 1

INSTITUTE OF METALS (joint meeting with the SOCIÉTÉ FRANCAISE DE MÉTALLURGIE, at Church House, Great Smith Street, London, S.W.1)—Spring Meeting.

Thursday, April 29

Informal Discussion on "Recovery and Recrystallization".

Tuesday, April 27

SOCIETY FOR ENDOCRINOLOGY (in the Barnes Hall, Royal Society of Medicine, 1 Wimpole Street, London, W.1), at 5.15 p.m.—Dr. Gregory Pincus: "Pathways of Steroid Synthesis in the Animal Organism".•

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Mr. S. L. Anderson: "Instruments for Testing and Control in the Textile Industry".

ROYAL AERONAUTICAL SOCIETY (in the Library, 4 Hamilton Place, London, W.1), at 7 p.m.—Mr. G. H. Lee: "Aerodynamic and Aeroelastic Characteristics of the Crescent Wing".

BRITISH SOCIOLOGICAL ASSOCIATION (at the Royal Society of Arts, 6 John Adam Street, Adelphi, London, W.C.2), at 8 p.m.—Prof. Talcott Parsons (Harvard): "A Reconsideration of the Problem of Social Evolution".

Wednesday, April 28

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 3 p.m.—Annual General Meeting.

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Annual General Meeting; Dr. O. G. Sutton, F.R.S.: "The Development of Meteorology as an Exact Science" (Presidential Address).•

PRESENTATION OF TECHNICAL INFORMATION DISCUSSION GROUP (in the Anatomy Theatre, University College, Gower Street, London, W.C.1), at 6 p.m.—Discussion on "The Techniques of Communication by Films". Chairman: Mr. K. Lockhart Smith.•

INSTITUTION OF MECHANICAL ENGINEERS, EDUCATION GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6.45 p.m.—Discussion on "The Mathematical Content of Engineering Courses".

Thursday, April 29

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 2.15 p.m.—Discussion on "The First and Second Viscosities of Fluids" opened by Prof. L. Rosenhead, F.R.S.

INSTITUTE OF FUEL (at the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Dr. D. T. A. Townend: "The New Education Scheme of the Institute of Fuel".•

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. A. Ratcliffe, F.R.S.: "The Physics of the Ionosphere". (The Forty-Fifth Kelvin Lecture.)

SOCIETY OF CHEMICAL INDUSTRY, ROAD AND BUILDING MATERIALS GROUP (in the Lecture Hall of the Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1), at 6 p.m.—Annual General Meeting. Mr. H. K. Purkis: "Control of Sound in Buildings—Requirements, Materials and Methods".

Friday, April 30

INSTITUTION OF CHEMICAL ENGINEERS (at the May Fair Hotel, Berkeley Street, London, W.1), at 11 a.m.—Thirty-second Annual Corporate Meeting.

TEXTILE INSTITUTE (at The Queen's University, Belfast), at 2.45 p.m.—Annual General Meeting. 3.45 p.m.—Dr. D. A. Clibbens: "Cellulose Chemistry and the Textile Industry".

CHEMICAL SOCIETY (in the Chemistry Lecture Theatre, The University, Liverpool), at 5 p.m.—Dr. R. H. Manske: "The Story of the Isoquinoline Alkaloids" (Centenary Lecture).

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Mr. S. B. Bailey: "Nodular Cast Iron: Its Present Position and Future Prospects as an Engineering Material, with Special Reference to its Suitability for Crankshafts".

UNIVERSITY OF LONDON (at the Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 5.30 p.m.—Dr. R. N. Jones: "Applications of Infra-Red Spectra to Organic Chemistry".•

SOCIETY OF CHEMICAL INDUSTRY, FINE CHEMICALS GROUP (at the National Institute for Medical Research, The Ridgeway, Mill Hill, London, N.W.7), at 7 p.m.—Dr. R. K. Callow: "Medical Research and Fine Chemicals".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. M. Postan: "Medieval Science and Technology".

Saturday, May 1

ASSOCIATION OF CLINICAL BIOCHEMISTS, SOUTHERN REGION (at the Radcliffe Infirmary, Oxford), at 2 p.m.—Demonstrations and Scientific Papers.

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SENIOR LECTURER IN MATHEMATICS at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 30).

ASSISTANT LECTURER IN GENETICS or CYTOLOGY—The Registrar, The University, Sheffield (May 1).

LECTURER and an ASSISTANT LECTURER IN THE DEPARTMENT OF PURE MATHEMATICS—The Registrar, The University, Liverpool (May 1).

LECTURER IN EDUCATIONAL PSYCHOLOGY at the University of Natal, Durban, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (South Africa, May 1).

LECTURER or ASSISTANT LECTURER (preferably with qualifications and experience in chemical engineering or a branch of chemical technology) IN THE DEPARTMENT OF CHEMISTRY, at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (May 1).

LECTURER (preferably with special qualifications in survey) IN GEOGRAPHY—The Secretary of University Court, The University, Glasgow (May 1).

SENIOR LECTURER and a LECTURER (with an honours degree, and preferably with teaching and industrial experience) IN THE DEPARTMENT OF CHEMISTRY—The Clerk to the Governing Body, College of Technology, Birmingham (May 1).

SENIOR LECTURER (with qualifications and experience necessary to plan and supervise the teaching of organic chemistry up to honours degree standard) IN ORGANIC CHEMISTRY—The Principal, Royal Technical College, Salford 5 (May 1).

UNIVERSITY LECTURER IN THE DEPARTMENT OF ANIMAL PATHOLOGY, to undertake teaching and research in veterinary parasitology—The Secretary, Appointments Committee of the Faculty of Biology "B", Department of Pathology, Tennis Court Road, Cambridge (May 1).

DEMONSTRATOR (honours graduate in chemistry or biochemistry) IN CHEMICAL PATHOLOGY—The Registrar, The University, Leeds 2 (May 3).

LECTURER or ASSISTANT LECTURER IN AERONAUTICAL ENGINEERING, a LECTURER IN ELECTRICAL ENGINEERING, an ASSISTANT LECTURER IN GEOLOGY, and an ASSISTANT LECTURER IN MATHEMATICS—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (May 3).

SENIOR SCIENTIFIC OFFICER (with first- or second-class honours degree in chemistry or equivalent, and at least three years postgraduate research, and a thorough knowledge of the mass spectrometer and experience in its application) IN THE CHEMICAL RESEARCH LABORATORY, Department of Scientific and Industrial Research, Teddington—The Secretary, Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S4314/54 (May 6).

HEAD OF THE DEPARTMENT OF GEOLOGY at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (May 7).

LECTURER IN MATHEMATICS at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (May 7).

LECTURER IN BACTERIOLOGY AND VIRUS DISEASES—The Registrar, The University, Sheffield (May 8).

ASSISTANT ENTOMOLOGIST (with at least a second-class honours degree in science, with entomology as a major subject) at the Wattle Research Institute, University of Natal, Pietermaritzburg—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (South Africa, May 15).

LECTURER or ASSISTANT LECTURER (preferably with qualifications in nuclear physics and electronics) IN PHYSICS—The Secretary, University College of the South-West, Exeter (May 15).

ASSISTANT LECTURER IN ANATOMY, to undertake teaching and research—The Secretary, University College London, Gower Street, London, W.C.1 (May 21).

CHAIR OF APPLIED ELECTRICITY—The Secretary and Registrar, University College of North Wales, Bangor, N. Wales (May 24).

READER IN PURE MATHEMATICS at King's College—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 25).

ASSISTANT LECTURER IN GEOLOGY—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (May 29).

CHAIR OF PHYSICAL OR INORGANIC CHEMISTRY—The Secretary, Queen's University, Belfast (May 31).

CHAIR OF PURE MATHEMATICS—The Secretary, The University, Birmingham 3 (May 31).

LECTURER IN PHYSICS at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (May 31).

BROTHERTON RESEARCH FELLOW IN PHYSICAL CHEMISTRY, and a RESEARCH ASSISTANT IN DYEING, in the Department of Colour Chemistry and Dyeing—The Registrar, The University, Leeds 2 (June 1).

RESEARCH ASSISTANT IN MATHEMATICAL STATISTICS and a RESEARCH ASSISTANT IN NUMERICAL ANALYSIS, in the Department of Applied Mathematics—The Registrar, The University, Liverpool (June 1).

LECTURER (with a university degree, preferably in forestry, and practical experience of forestry in Great Britain or abroad) IN FORESTRY—The Secretary, The University, Edinburgh (June 15).

DEMONSTRATOR (preferably with a degree and some ability in the experimental testing of rockets, ram jets, gas turbine combustion chambers, or other aspects of modern power plants) IN THE DEPARTMENT OF AIRCRAFT PROPULSION—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

LECTURER (with a degree in horticulture or horticultural botany) IN HORTICULTURE, in the Faculty of Agriculture, Makerere College (University College of East Africa)—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1.

METALLURGISTS, Experimental Officer grade (with at least H.S.C. in science subjects) in the Department of Atomic Energy, Salwick, near Preston, for development work up to pilot plant scale for the reduction or fabrication, including casting, mechanical working, welding and powder metallurgy, of unusual metals—The Department of Atomic Energy, Industrial Group Headquarters, Risley, Warrington, quoting 572.

PERRING SCHOLAR (preferably honours graduate or final year undergraduate in engineering, mathematics or physics) IN AERONAUTICS—The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks.

PHYSICISTS (with a good honours degree and some experience or training in research, not necessarily in textile research) to work on textile problems—The Secretary, British Rayon Research Association, Barton Dock Road, Urmston, near Manchester.

SCIENTIFIC ASSISTANT (with a university degree, and a knowledge of two or more European languages, and ability to write clear, concise English), for duties which include abstracting world scientific literature on animal breeding, genetics and production—The Director, Commonwealth Bureau of Animal Breeding and Genetics, King's Buildings, Edinburgh 9.

SCIENTIFIC OFFICER (with a first- or second-class honours degree in physics or engineering, or equivalent qualifications, and at least three years postgraduate research experience) to supervise and participate in the activities of a group investigating the mechanical properties under stress (including tests to mechanical destruction) of prototype atomic weapons—The Administrative Officer Recruitment Section, Atomic Weapons Research Establishment, Aldermaston, quoting 106/WGE/2.

SCIENTIFIC OFFICERS (3) (with first- or second-class honours degree in inorganic or physical chemistry, or equivalent qualifications), at the Water Pollution Research Laboratory, Department of Scientific and Industrial Research, Stevenage, to study the effects and treatment of pollution of rivers by waste waters containing inorganic and organic impurities—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.227/54A.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Parliamentary and Scientific Committee. (An unofficial group of Members of both Houses of Parliament, and representatives of certain scientific and technical institutions.) Annual Report, 1953. Pp. 28. (London: Parliamentary and Scientific Committee, 1954.) [122

Privy Council. Agricultural Research Council. Index of Agricultural Research in Progress during 1953–54. Pp. ix+118. (London: H.M. Stationery Office, 1954.) 5*s*. net. [122

University of Leeds: The Brotherton Collection. The Eighteenth Annual Report of the Brotherton Collection Committee, Session 1952–53. Pp. 10. (Leeds: University of Leeds, 1954.) [122

The Rowett Research Institute. Collected Papers with Summarised Account of Contents. Vol. 10. Pp. 24. (Bucksburn: Rowett Research Institute, 1954.) [122

Careers in Agricultural Research. Training Grants, Studentships and Fellowships awarded by The Agricultural Research Council. Pp. 14. (London: Agricultural Research Council, 1954.) [122

Department of Scientific and Industrial Research and Fire Offices' Committee. Fire Research, Special Report No. 2: Heat Transfer by Radiation. By J. H. McGuire. Pp. v+29. (London: H.M. Stationery Office, 1953.) 1*s*. 6*d*. [152

Transactions of the Edinburgh Geological Society. Session 1953–54. Vol. 16, Part 1: Catalogue of Type and Figured Specimens of Fossil Fishes and Amphibians in the Royal Scottish Museum, Edinburgh. By Dr. Charles D. Waterston. Pp. x+91. (Edinburgh and London: Oliver and Boyd, Ltd., 1954.) 7*s*. 6*d*. (to Fellows 6*s*.). [152

National Museum of Wales. Forty-Sixth Annual Report, 1952–53. Pp. 63. (Cardiff: National Museum of Wales, 1953.) [152

Annual Report of the National Oceanographic Council. 1 April 1952–31 March 1953. Pp. v+34+3 plates. (Cambridge: At the University Press, 1954.) 5*s*. net. [152

Bulletin of the British Museum (Natural History). Historical Series. Vol. 1, No. 2: Louis Auguste Deschamps. By C. G. G. J. Van Steenis, M. J. Van Steenis-Kruseman and A. Backer. Pp. 49–68+plate 13. 6*s*. Zoology. Vol. 2, No. 4: The Macrotritopus Problem. By Dr. W. J. Rees. Pp. 67–100+plate 3. 12*s*. Vol. 2, No. 5: Hearing in Cetaceans. By F. C. Fraser and P. E. Purves. Pp. 101–114+plates 4 and 5. 4*s*. (London: British Museum (Natural History).) [152

A Career in the Gas Industry. Pp. 24. (London: The Gas Council, 1954.) [152

Current Iodine Literature. List No. 1, 1954. Pp. 13. (London: Chilean Iodine Educational Bureau, 1954.) [152

British Museum (Natural History). The John Murray Expedition 1933–34. Scientific Reports. Vol. 10, No. 2: Scaphopoda. Pp. 91–120+1 plate. (London: British Museum (Natural History), 1954.) 7*s*. 6*d*. [152

Scottish Home Department. Report of the Scottish Peat Committee. Pp. 66+8 plates. (London: H.M. Stationery Office, 1954.) 5*s*. net. [152

Aero Research Technical Notes. Bulletin No. 133: Tropical Exposure Tests on "Aerolite" 300. Pp. 4. (Duxford: Aero Research, Ltd., 1954.) [162

Scottish Home Department. Freshwater and Salmon Fisheries Research. No. 6: Fifth Annual Report of the Supervisory Committee for Brown Trout Research 1952–1953. Pp. 12. (Edinburgh: H.M. Stationery Office, 1954.) 2*s*. net. [162

Other Countries

Yale Medical Library. Annual Report including the Report of the Historical Library, 1952–1953. Pp. 42. (New Haven, Conn.: Yale Medical Library, 1953.) [32

Institut de France. Académie des Sciences. Annuaire pour 1954. Pp. 356. (Paris: Gauthier-Villars, 1954.) n.p. [32

A Brief Description of the Timbers included in the Malayan Grading Rules. By A. V. Thomas. Pp. ii+15. (Singapore: Government Printing Office, 1953.) 50 cents. [42

United States Naval Observatory. Circular No. 46: Positions, Areas, and Counts of Sunspots, August–September–October, 1953. By Winifred Sawtell. Pp. 8. (Washington, D.C.: U.S. Naval Observatory, 1953.) [42

Proceedings of the California Academy of Sciences. Fourth Series. Vol. 28, No. 4: Natural History of the Pallid Bat, *Antrozous Pallidus* (Le Conte). By Robert T. Orr. Pp. 165–246. (San Francisco: California Academy of Sciences, 1954.) [52

Joint Establishment for Nuclear Energy Research. Second Annual Report, 1952/53. Pp. iv+41. (Blindern, Oslo: Akademisk Trykningssentral, 1953.) [52

Deutsche Akademie der Wissenschaften zu Berlin: Institut für Physikalische Hydrographie. Acta Hydrophysica. Band 1, Heft 1, 1953. Pp. 56. (Berlin: Akademie Verlag, 1953.) [122

Sveriges Geologiska Undersökning. Ser. C. No. 518. Arsbok 44 (1950) No. 4: Vissa Amnens Fordelning I Marken I Kopparbergs Län. Av O. Arrhenius. Pp. 40. (Stockholm: Kungl. Boktryckeriet. P. A. Norstedt and Söner, 1953.) 2.50 kronor. [152

Tobacco Research Board of Southern Rhodesia. Report of Progress 1951–1953. (Bulletin 3.) Pp. 48. (Kutsaga: Tobacco Research Board of Southern Rhodesia, 1953.) [152

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Flore du Congo Belge et du Ruanda-Urundi, préparéepar le Comité exécutif de la Flore du Congo Belge et le Jardin Botanique de l'État. Spermatophytes—Vol. 4. Pp. vi+314. 300 francs. Serie Scientifique, No. 58: l'Alimentation Minérale du Cacaoyer (*Theobroma Cacao* L.). Étude publiée sous la direction de Prof. Marcel V. Homès. Pp. 128. 125 francs. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1953.) [152

Ceskoslovenska Akademie Ved. Publikage Astrofysikalni Observatore, Ondrejov. No. 25: Katalog Mesicnich Zatmeni 1889–1938. 1: Zvetseni Zemskeho Stinu. By F. Link and Z. Linkova. Katalog Mesicnich Krateru. By J. Bouska, F. Hrebik and Z. Svestka. Pp. 116. (Praha: Nakladatelstvi Ceskoslovenske Akademie Ved., 1953.) [152

Rocznik Astronomiczny. Obserwatorjum Krakowskiego, 1954. (Nr. 25.) Dodatek Miedzynarodowy: Supplemento Internationale. Wydal T. Banachiewicz. Pp. ix+96. (Krakow: Obserwatorjum Krakowskiego, 1954.) [152

Mitteilungen des Deutschen Wetterdienstes. No. 6: Berechnung der Verdunstung aus klimatologischen Daten. Von Dr. Siefried Uhlig. Pp. 24. (Bad Kissingen: Deutschen Wetterdienstes, 1954.) [152

Associations. (The Review of International Organizations and Meetings.) (Formerly "NGO Bulletin".) January, 1954. Pp. 64. (Bruxelles: Union of International Associations, 1954.) [152

Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac. Vol. 13, Part 4: Coordinates of the Center of Mass of the Sun and the Five Outer Planets 1800–2060. By G. M. Clemence. Pp. viii+323–364. (Washington, D.C.: Government Printing Office, 1953.) 55 cents. [152

Kungl. Svenska Vetenskapsakademiens Handlingar. Fjärde Serien. Band 4, No. 5: Die Diatomeen von Schweden und Finnland. Teil 3: Monoraphideae, Biraphideae 1. Pp. 256+41 plates. (Stockholm: Almqvist and Wiksells Boktryckeri-AB.; London: H. K. Lewis and Co., Ltd., 1953.) 62.50 kronor. [152

Canada. Department of Mines and Technical Surveys. Publications of the Dominion Astrophysical Laboratory, Victoria, B.C. Vol. 9, No. 8: Absolute Magnitudes of the B Stars Determined from Measured Intensities of the $H\gamma$ Line. By R. M. Petrie. Pp. 251–268+1 plate. Vol. 9, No. 9: Hydrogen Absorption Lines in the Spectra of B-Type Stars. By Jean K. McDonald. Pp. 269–296+1 plate. Vol. 9, No. 10: Wave-Length Standards for Radial-Velocity Determinations from B-Type Spectra. By R. M. Petrie. Pp. 297–320+1 plate. (Ottawa: Queen's Printer, 1953.) [152

Institut Royal des Sciences Naturelles de Belgique. Mémoires. Deuxième série, Fasc. 45: Ph. Dautzenberg's Collection of Cypraeidae. By Dr. F. A. Schilder and Dr. M. Schilder. Pp. 244+4 plates. Deuxième série, Fasc. 48: Dispersion Geographique des Glossines au Congo Belge. Par Frans M. J. C. Evens. Pp. 70. Deuxième série, Fasc. 49: Origine des Ptychodontes. Par Dr. Édgard Casier. Pp. 52+2 plates. Deuxième série, Fasc. 50: Les Chrysomeloidea (Coleoptera) des Iles Baléares. Par Pierre Jolivet. Pp. 88+3 plates. Mémoire No. 125: Three Abietaceous Cones from the Wealden of Belgium. By Kenneth Leonard Alvin. Pp. 42+5 plates. (Bruxelles: Institut Royal des Sciences Naturelles de Belgique, 1953.) [152

Institut Royal des Sciences Naturelles de Belgique. Expédition Océanographique Belge dans les Eaux Côtieres Africaines de l'Atlantique Sud (1948–1949). Résultas Scientifiques. Vol. 4, Fasc. 2: Poissons, 3–Téléostéens Malacoptérygiens. Par Max Poll. Pp. 258+8 plates. (Bruxelles: Institut Royal des Sciences Naturelles de Belgique, 1953.) [152